Final Report

to

Study Cooperators

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Population Ecology of Black Bears in the Okefenokee-Osceola Ecosystem

Abstract: We studied black bears (*Ursus americanus*) on 2 study areas in the Okefenokee-Osceola ecosystem in north Florida and southeast Georgia from 1995–1999 to determine population characteristics (size, density, relative abundance, distribution, sex and age structure, mortality rates, natality, and recruitment) and habitat needs. We captured 205 different black bears (124M: 81F) 345 times from June 1995 to September 1998. Overall, adult bears on Osceola were 19% heavier than those on Okefenokee ($t = 2.96$, df = 148, $P = 0.0036$).

We obtained 13,573 radiolocations from 87 (16M:71F) individual bears during the period of study. Seventeen mortalities of radiocollared bears were documented on Okefenokee, with hunting mortality accounting for 70.6% of these deaths. We documented only 2 (8%) mortalities of radiocollared females from Osceola; both were illegally killed. Annual survival rates for radiocollared females were lower on Okefenokee ($\bar{x} = 0.87$, 95% CI = 0.80–0.93) than on Osceola ($\bar{x} = 0.97$, 95% CI = 0.92–1.00; $\chi^2_{0.05} = 3.98$, 1 df, $P = 0.0460$). Overall, 67 bears (51M:16F) were taken by hunters on the Okefenokee study area from 1995–1999. Including the bears that were in protected areas and unavailable to harvest, the annual harvest rate was 10.1%. Our annual survival estimate for Osceola females (0.97) was among the highest reported from any southeastern bear population, no doubt influenced by the closing of the bear hunting season in and around Osceola NF in 1992. When survival estimates for Okefenokee females were recalculated without hunting mortality, overall survival rates increased from 0.87 to 0.95, similar to that of the Osceola females.

To estimate population size, we maintained 88 and 94 barbed wire hair traps during 1999 on the Okefenokee and Osceola study areas, respectively. Complete multi-locus genotypes were obtained for 78 (99%) of the Okefenokee samples, of which 39 individual bears were identified. On the Osceola study area, complete genotypes were obtained for 84 (96%) samples representing 37 individuals. After considering a number of mark-recapture estimators, we concluded that the within-year estimate of 71 bears

(95% CI = 59–91) produced by the jackknife heterogeneity model M_h was the most appropriate for the Okefenokee hair-trapping data. Likewise, we selected the estimate of 44 bears (95% CI = 40–57) on the Osceola study area provided by the null model M_o as most appropriate during 1999. The estimated densities of black bears on the Okefenokee and Osceola study areas were 0.14 and 0.12 bears/km^2, respectively. Based on a weighted average density of 0.135 bears/km^2 and assuming a homogeneous distribution, we estimate that approximately 830 bears (95% CI = 707–1,045) inhabit the 6,147-km^2 Okefenokee-Osceola ecosystem.

We monitored 66 radiocollared bears (8M:58F) from 1995–1998 for 132 possible denning occasions. Denning durations for females ($\bar{x}$ = 96.7 days, n = 109, SE = 2.7) were longer than for male bears ($\bar{x}$ = 71.6 days, n = 9, SE = 8.8; Z = -2.38, P = 0.0174). Two male bears from Okefenokee denned in ground nests whereas tree cavities (n = 18) and ground nests (n = 16) accounted for 65% of all dens used by Okefenokee females. In contrast, ground nests accounted for 100% (n = 37) of all documented den types used by female bears on the Osceola study area. Bears on Okefenokee used shrub, blackgum, mixed shrub, and cypress habitat types on 24, 23, 21, and 13 occasions, respectively. Interestingly, 90% (n = 74) of all radiocollared bears on the Okefenokee study area denned within the boundaries of ONWR during 1995–1998. Only 1 radiocollared female from each area denned in pine habitat during this study.

Mean litter sizes did not differ between Okefenokee ($\bar{x}$ = 2.1, n = 34, SE = 0.64) and Osceola ($\bar{x}$ = 2.1, n = 22, SE = 0.68) females. Annual cub production, however, differed between the 2 areas. On the Osceola study area, 46 cubs were born from 8, 5, and 9 litters in 1997, 1998, and 1999, respectively. In contrast, 99% (n = 69) of all documented cub births on the Okefenokee area occurred in 1997 and 1999. Only 1 of 15 solitary females on the Okefenokee study area produced cubs in 1996.

When the average annual harvest from 1995–1999 (9.4 animals or 13.2%) was imposed on the population for 10 years beginning in 1999, the average annual growth rate was 0.916 (SD = 0.072) and the population declined to 30.6 (SD = 20.5). Extinction occurred in 0.6% of the simulations over the 10-year period and in 58.3% after 25 years. When the average annual harvest level was reduced to 5 bears (7.0%), population growth was stable at 0.993 (SD = 0.076). Beginning in 1999 and based on a population size estimate of 44 at Osceola, the average annual growth rate of the population without a harvest over the following 10 years was 1.184 (SD = 0.071), higher than at Okefenokee ($t = 3.93$, 18 df, $P = 0.0010$). Average growth rates for both study areas indicated some reproductive synchrony, but to a lesser extent than on the Okefenokee study area as evidenced by changes in growth rates by year. No extinctions occurred with this modeling scenario after 25 years.

Although our population simulations suggest overexploitation was occurring at Okefenokee, the simulations were of a closed population and, therefore, did not include immigration or emigration. Our data suggest that both occurred on the Okefenokee study area. Of our radiotagged bears, the average emigration rate over the 5 years of study was 0.13 (SD = 0.15). In 1999, however, none of the 25 bears that we monitored left the study area. This suggests dispersal from the Okefenokee population that averaged 9.2 annually (based on a population estimate of 71 bears), and may have been as few as zero in 1999. Conversely, Jolly-Seber models enabled us to estimate recruitment, which includes both births and immigration. Given our simulation parameters, we can expect births to average about 16.6% of the population annually or about 11.8 cubs/year given our starting population size of 71. Model B estimated total recruitment in 1999 as 28 bears, thus we can expect that immigration would be approximately 16 bears (22%). These 16 immigrants were offset by an average loss of 9.2 emigrants each year, for a net gain of approximately 7 animals or 10%. Based on that, the average sustainable harvest of 5 bears (7%) that we calculated could be increased to approximately 12 (17%), which is greater than the average annual 1995–1999 harvest of 9.4 (13.2%). Thus, it appears that the harvest levels on the Okefenokee study area were sustainable, but not without the immigration that occurred.

On the Osceola study area, average annual population growth averaged 1.184, a high rate for the species. Our mark-recapture data from Osceola suggested a high dispersal rate by subadult bears, and our population modeling data support that hypothesis. Young recruits dispersed into surrounding habitat; we documented bears on the Okefenokee study area that originated from the Osceola study area but not the converse. Thus, our data suggest that immigration is crucial to the sustainability of the hunted portion of the overall bear population and that bears from within the ONWR and Florida provide these surplus immigrants.

Between June 1995 and December 1999, we identified 32 separate food items in 2,160 bear scats (1,457 Okefenokee, 703 Osceola). Sweet gallberry (*Ilex coriacea*) occurred most frequently and accounted for 32% and 23% of summer scats by volume on Okefenokee and Osceola, respectively. By volume, saw palmetto (*Serenoa repens*) and grapes (*Vitis* spp.) accounted for the majority of soft mast in summer scats. Apart from shrub/vine fruits, corn was the second most important food item in the summer diets of Okefenokee and Osceola bears, representing 24% and 39% of summer scats by volume on Okefenokee and Osceola, respectively. In September, bears on Okefenokee began feeding on blackgum (*Nyssa sylvatica*), which volumetrically accounted for 9% of the total summer diet. Blackgum appeared only in trace amounts on Osceola during summer months.

Although summer diets were proportionally similar on Okefenokee and Osceola, fall diets varied considerably between the 2 areas. On Osceola, corn accounted for 40% of fall scats by volume, but represented only 2% of the volume on Okefenokee. In contrast, tree fruit dominated the fall diet on Okefenokee, with blackgum and acorns (*Quercus* spp.) accounting for 37% and 21% of scats by volume. The remainder of the fall diet primarily consisted of palmetto fruit, which accounted for 30% and 33% of the volume on Okefenokee and Osceola, respectively.

Blackgum accounted for $\geq$16% of annual scat volume on Okefenokee each year of this study. Following a blackgum shortage in 1995, we observed an unusually abundant crop in 1996; this was reflected in our scat analysis. The same pattern was repeated in 1997 and 1998 on Okefenokee. On the Osceola study area, however, blackgum accounted for <4% of scat volume each year except 1998 (29%).

Osceola bears exploited corn from deer (*Odocoileus virginianus*) feeders each year of the study. From 1996–1999 on Osceola, corn accounted for 15%, 53%, 48%, and 30% of scat volumes, respectively. Although shrub/vine fruits accounted for $\geq$19% of scat volume each year on Osceola, they exhibited annual fluctuations in abundance. The supply of corn, however, was relatively stable on the Osceola area. Interestingly, shrub/vine fruits were especially abundant in 1996 and 1999, and accounted for 78% and

60% of the annual scat volumes. The lower use of corn during years of abundant shrub/vine fruits, particularly saw palmetto, suggests that bears prefer natural foods when available.

Our telemetry data indicate that, in years of abundant blackgum production, bears retreated to swamp habitats and remained until the onset of denning. During the heavy crop of blackgum in 1996, only 1 of 22 radiocollared females traveled outside Okefenokee National Wildlife Refuge (ONWR) after mid-October. More importantly, we observed high reproductive success in 1996, with 21 of 22 radiocollared females producing cubs. This is a striking contrast to 1995 when, during a blackgum shortage, only 1 of 15 radiocollared females produced cubs. Females were still in reproductive synchrony at the conclusion of this study in 1999, indicating a strong positive relationship between blackgum and cub production in and around the Okefenokee study area.

Annual home range size for males and females on the Okefenokee study area averaged 342.8 km^2 (n = 10, SE = 71.5) and 55.9 km^2 (n = 69, SE = 6.9), respectively. The mean annual home range size for Osceola females ($\bar{x}$ = 30.3 km^2, n = 53, SE = 4.0) was roughly half that of Okefenokee females (Z = -2.47, P = 0.0136). Across years, fall was the only season when we observed dramatic fluctuations in female home range size. This was most apparent in 1998 and 1999, when mean home range size increased from 14.5 km^2 to 78.4 km^2 for Okefenokee females.

Estimates of annual home range size for Okefenokee bears during this study were larger than those reported from most black bear populations in North America. In contrast, home range estimates for females at Osceola were significantly smaller than Okefenokee and fell within the range of other bear populations. Food availability and abundance appears to be the primary reason for differences in home range size and shape between the Okefenokee and Osceola areas. Home ranges on Okefenokee included relatively large areas as bears were forced to seek out blackgum and palmetto fruit. In contrast, bears on the Osceola area were much less reliant on natural foods because of the readily available and abundant supply of corn from deer feeders. Based on the similarity of habitats within the 2 areas, and because corn accounted for 37% of the annual diet of Osceola bears compared to <5% on Okefenokee, it appears that corn from deer feeders enabled Osceola bears to meet their nutritional requirements within substantially smaller home ranges.

Not surprisingly, we detected no difference between seasonal home range sizes for female bears on the Osceola study area. For Okefenokee females, however, the reliance on natural foods appeared to influence the size and location of seasonal home ranges. During summer, foods were usually patchily distributed and often were available only for relatively short periods of time. During fall, female home ranges on Okefenokee were smaller when food items were more abundant. We observed exceptions to this, however, during years when blackgum production was low. The most extreme case of seasonal home range expansion occurred during fall 1999 following an abundant blackgum crop in 1998 when average fall home range size increased more than 4-fold for Okefenokee females. We also observed an unusually abundant crop of palmetto fruit in 1999 that remained available throughout the fall. Consequently, many radiocollared females expanded their home ranges into upland habitats away from ONWR during that time. As a likely result, 5 females were harvested on the Okefenokee study area during the 1999 bear hunting season. That was a dramatic increase considering that only 7 females were harvested on the study area from 1996–1998. On Osceola, seasonal home ranges varied little, again probably because of the widely available corn feeders.

To evaluate microhabitat use, we characterized movement patterns as Rest, Forage, Search, or Travel events. Only the Rest movement category showed significant differences between the cover types ($F_{3,15} = 8.94$, $P < 0.05$). Pine Plantation and Forest Regeneration were used proportionately less ($P < 0.05$) for Rest events, whereas the Wetland Mixed Forest was used proportionately more. Wetland Mixed Forest and Pine Plantation were the dominant habitat types, with 27.5% and 43.5% available to bears, respectively. Bears collectively spent over twice as much time (607 h) in Wetland Mixed Forest as they did in Pine Plantation (253 h). Cumulative time spent within other cover types was minimal when compared to Wetland Mixed Forest and Pine Plantation.

We used compositional analysis to evaluate macrohabitat use. On the Okefenokee study area, loblolly bay habitats ranked highest among the 7 habitat types at the second-order level. Although a difference ($P = 0.0068$) in use was detected between loblolly bay and blackgum/bay/cypress, each showed significantly greater use than all remaining habitat classifications. Pine/oak associations accounted for only 6.4% of the Okefenokee study area yet showed a greater proportional use (P = 0.0005) than pine habitats, which comprised 27.5% of the available area. For Okefenokee females, there were no changes in position for the 4 highest ranked habitat types between second and third-order selection. For the within-home range analysis, however, we detected no difference in use between loblolly bay and blackgum/bay/cypress (P = 0.1303) or between pine/oak and pine (P = 0.7797). Swamp forest habitats ranked fifth overall and was used significantly more than the remaining habitat types ($P \leq 0.0213$).

Analysis of second-order selection for the Osceola study area indicated female home ranges were primarily located around blackgum/bay/cypress habitats relative to all other classifications. For third-order selection, blackgum/bay/cypress habitats and swamp forests ranked highest among all habitat types. Pine stands, which ranked second in relation to where home ranges were located within the Osceola area, ranked only fifth in habitat use at third-order selection.

We identified and described 51 beeyards on the Okefenokee study area. Of the 44 bears (8M:36F) whose home ranges met sample size requirements, only 28 (8M:20F) contained $\geq$1 beeyard. Of those bears, 4 (3M:1F) were trapped as nuisance bears at recently raided beeyards. Distances to riparian zones were less for damaged ($\bar{x}$ = 1,750 m) compared to undamaged yards ($\bar{x}$ = 4,442 P = 0.0089) and damaged beeyards were closer to roads ($\bar{x}$ = 134 m) than undamaged beeyards ($\bar{x}$ = 802 m, P = 0.0089). From 1996–1998, 13 instances of bears raiding beeyards were documented; 7 occurred within the Okefenokee study area boundaries. All but 1 of the raided yards were enclosed with some form of electric fence. In all instances when the damage occurred, the fence was not active because of depleted batteries.

Although the estimated densities of bears were similar between the Okefenokee and Osceola study areas, other aspects of population dynamics represent opposite ends of the spectrum. Corn from deer feeders was the most probable reason for differences in weights between Okefenokee and Osceola bears. That, in turn, was a likely reason for higher reproductive output among Osceola females, reflected mostly in the proportion of eligible females producing cubs. Additionally, the corn influenced home range sizes, productivity, and immigration rates to surrounding areas. In addition to the corn feeders, protection from hunting on Osceola has resulted in high population growth and a high emigration rate of among subadults. Conversely, on the Okefenokee study area, mortality from hunting is high but sustainable because of the constant influx of immigrants. We speculate that bears from refugia within ONWR, and to some extent Florida, fueled the high population turnover caused by hunting mortality in the surrounding Georgia counties. That harvest is influenced by the production of blackgum, which makes bears less vulnerable during high-production years. In poor years, bears are forced to forage on upland areas for palmetto and gallberry, and are extremely susceptible to harvest by hunters.

A major component of bear management surrounding the Okefenokee Swamp will involve harvest regulation. Harvest levels have fluctuated annually and our radiotelemetry data indicate that during periods of blackgum scarcity, bears make use of upland habitats and, when they do so, stand a high chance of being killed by hunters. Consequently, harvests can be expected to continue to fluctuate and should be designed to accommodate those extremes.

Clearly, bears in the Okefenokee-Osceola ecosystem could not survive without the security provided by the swamp itself. Few bears lived year-round on the Okefenokee study area without making use of swamp habitats. On the Osceola study area by contrast, bears made extensive use of upland habitats but that was heavily influenced by the presence of corn feeders. Even so, riparian habitats were critical on the Osceola area and bears seemed to prefer natural foods when they were available. Despite their reliance on wetlands, upland habitats were also important to bears for soft mast production (e.g., palmetto and gallberries), particularly during periods of blackgum scarcity. Private lands were particularly important for providing such upland soft mast. The increased use of herbicides on private land for timber management could have negative consequences for bears by reducing or eliminating such upland soft mast foods. Additionally, more frequent burning rotations to promote longleaf pine (*Pinus palustris*)-wiregrass (*Aristida stricta*) ecosystems on public lands could have a similar effect. It is important to monitor changes in bear foods in habitats where these management practices have been affected.

Man is a critical element in black bear population dynamics; where bears are not tolerated by man, they do not exist. Our data suggest that working electric fences are an effective deterrent to bear damage to beeyards, even in areas frequented by bears. Given proper maintenance, electric fencing should prevent almost all nuisance bear problems in and adjacent to our study areas. Additionally, hunting is an important recreational activity in the region and it has significant impacts on the bear population. If properly regulated, hunting and training bear dogs adds value to bears and helps garner local support for their management. In Florida where bears are no longer hunted, locals often viewed them as a liability rather than an asset. Viewpoints by locals in Georgia were more positive. Finally, bears have significantly benefited from the deer baiting that takes place in Florida. Should that practice suddenly cease, negative consequences to the local bear population would surely result.

Although the Okefenokee-Osceola bear population is relatively large and clearly not in jeopardy, the long-term persistence of other Florida black bear populations is more questionable. Habitat loss and fragmentation and human encroachment are resulting in populations that are becoming increasingly isolated from other bear populations. Of the 7 recognized Florida black bear populations, the USFWS has concluded that only the Apalachicola NF, Ocala NF, Big Cypress National Preserve, and Okefenokee-Osceola ecosystem populations are viable. Our data support those conclusions at Okefenokee-Osceola. In contrast, the Chassahowitzka bear population, located on the central Gulf Coast of Florida, may contain <20 individuals and the south Alabama population may number <30. For these smaller, more isolated populations to persist into the foreseeable future, it may be necessary to augment them with bears from one of the larger populations. Bears from the Okefenokee-Osceola ecosystem could be candidates for such translocations.

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INTRODUCTION

Ecologically, aesthetically, and economically, the black bear is one of the primary vertebrate components of the Okefenokee Swamp-Osceola Ecosystem. Ecologically, bears are good indicators of ecosystem health because they are sensitive to land use changes and use their habitat at the landscape level (Simberloff 1999). Aesthetically, the black bear is a symbol of our remaining wilderness and is the only native large carnivore remaining in the region. Economically, bear hunts increase revenues to local economies through hunting license sales and related supplies, yet bears can become pests by raiding orchards, destroying beeyards, killing livestock, and eating garbage.

The range of the black bear has been significantly decreased by habitat loss and fragmentation (Pelton and van Manen 1997). In the southeastern United States, black bears currently are found in the Interior Highlands, the Appalachians, and the southeastern coastal plain (Fig. 1). Only 5–10% of their former range in the Southeast is currently occupied, making bears especially vulnerable to genetic inbreeding, habitat loss, and overharvest. Perhaps nowhere else in the country have bear populations become more fragmented than in this region (Hellgren and Maehr 1992).

Three subspecies of black bears exist within the southeastern coastal plain: the eastern black bear (*U. a. americanus*), the Louisiana black bear (*U. a. luteolus*), and the Florida black bear (*U. a. floridanus*). Historically, the Florida black bear occurred throughout Florida and in the coastal plain of Georgia, Alabama, and Mississippi (Hall 1981). Since the late 1800s, however, land clearing for agriculture and urbanization has significantly decreased available habitat in the southeastern U. S. More importantly, loss of those native forests has resulted in severe forest fragmentation and bear populations that are geographically isolated (Wooding and Hardisky 1994). The range of the Florida black bear has been reduced by nearly 83% (Brady and Maehr 1985; Florida Game and Freshwater Fish Commission, 1992, unpublished report) and now exists as 7 relatively disjunct populations in Alabama, Florida, Georgia, and possibly Mississippi (Fig. 1). The largest of these bear populations is found in the Okefenokee-Osceola ecosystem.
The Florida Game and Freshwater Fish Commission listed the Florida black bear as threatened in 1974 because of habitat destruction and illegal killing. Black bear hunting seasons were subsequently closed except in Baker and Columbia counties, Apalachicola

National Forest (NF), Osceola NF, and Tyndall Air Force Base where regulated harvests were allowed to continue. In 1990, the U. S. Fish and Wildlife Service (USFWS) was petitioned to list the Florida black bear as a federally threatened species under the Endangered Species Act of 1973. The petition cited illegal hunting, loss and fragmentation of habitat, hunting pressure, and road mortality as the primary justifications for federal protection (Kasbohm and Bentzien 1998). In 1992, the USFWS concluded that the status of the Florida black bear was “warranted but precluded” from official designation as a protected species by higher priority listing actions (Wooding 1992). Consequently, the Osceola NF was closed to bear hunting in 1992, and all black bear hunting seasons in Florida were terminated in 1994. Bear hunting on the northern periphery of ONWR in Georgia continued to occur.

A subsequent reexamiation by the USFWS to federally list this subspecies was mandated by a federal court. In 1998 it was ruled that, based on current biological data, the Florida black bear did not warrant federal protection (Kasbohm and Bentzien 1998). The USFWS reported that the largest of the remaining Florida black bear populations (Apalachicola NF, Ocala NF, Big Cypress National Preserve, and ONWR-Osceola NF) were viable and that habitat loss and fragmentation did not threaten their persistence because they were secure on public conservation lands (Bentzien 1998). It was concluded that, because those populations were distributed over most of the historical range of the species, the Florida black bear was not endangered or likely to become so in the foreseeable future (Bentzien 1998). The 1998 decision by the USFWS, however, drew criticism from some conservation groups and a lawsuit was filed in an attempt to overturn the settlement. In December 2001, the federal judge for this case directed the USFWS to readdress the listing decision, citing inadequate regulatory measures (J. Kasbohm, USFWS, personal communication). Thus, the future listing status of the subspecies remains uncertain.

The Okefenokee-Osceola ecosystem has been regarded as one of the last strongholds for the Florida black bear, primarily because of the area’s isolation, large size, and inaccessibility to humans. Although the subspecies has been studied in other areas (Maehr and Brady 1982, 1984; Seibert 1993; Freedman 2000; Stratman and Pelton 1999; Edwards 2002), and a limited number of bears were radiocollared in Osceola NF

(Mykytka and Pelton 1990, Wooding and Hardinsky 1994), no intensive research studies on the bears of the Okefenokee-Osceola ecosystem have taken place.

Undoubtedly, the long-term future of black bears in the area will rest on our ability to provide them with quality habitat. Black bears use habitats at the landscape scale, thus, their home ranges transcend jurisdictional and ownership boundaries. Including the private lands, there are well over 1 million acres (404,700 ha) of existing and potential black bear habitat in the Okefenokee-Osceola ecosystem that should be managed in a coordinated, integrative manner. We need to know whether the mosaic of state, federal, and private lands in the region provide an adequate mix of habitat components to meet the long-term needs of the bear population. At a more localized scale, a variety of issues should be addressed such as the effects of current management practices (e.g., agriculture, silviculture, urbanization) and the management opportunities for bears provided by such practices (e.g., timber regeneration, prescribed fire).

Another important aspect of bear biology and bear-human interactions in the region is beekeeping. Beekeeping is an important industry in southeast Georgia and north Florida. Quality bee range within the study area often coincides with bear habitat and bears can become an economic liability by destroying apiaries. Under Georgia law, relocation was the only management technique to deal with offending bears that raided properly fenced beeyards; killing was not permitted. The lack of effective regulation, as perceived by beekeepers, has generated negative attitudes about the management agencies and black bears. Management agencies, on the other hand, want to address these damage issues, but without compromising the status of this isolated bear population. Consequently, there is a need to assess landowner attitudes toward bears, estimate the extent of beeyard losses to bears in the area, and evaluate methods to reduce bear depredations to apiaries.

More immediate concerns for black bears in the area include the impact of legal and illegal take. Bear hunting in Florida ended with the 1993–1994 season. As a result of that closure in Florida, increased hunting pressure on black bears along the northern periphery of the ONWR has occurred (W. Abler, Georgia Department of Natural Resources, personnel communication). The bear harvest in south Georgia typically was low (25–50 bears) but the sustainability of the population is unknown as is the level of illegal mortality. Although the Okefenokee–Osceola bear population may well be capable of supporting a sustainable harvest, more accurate demographic data are needed.

Thus, the focus of this research was to determine population characteristics (size, density, relative abundance, distribution, sex and age structure, mortality rates, natality, and recruitment) and habitat needs of the Okefenokee-Osceola black bear population. With that information, we can then assess the impacts of land management practices and the effect of natural, legal, and illegal mortality on the population. Finally, our objective was to determine population growth, sustainable yield, and factors influencing population dynamics of the species.

Specific objectives were to:

1) determine mortality rates, reproductive success, home range dynamics, and habitat use patterns, and relate each to land management practices at the stand and landscape levels, and

2) estimate the current rate of population growth and evaluate the effects of current levels of hunting on the bear population. Another goal was to assess other human activities and land management practices (e.g., effects of roads, beekeeping, hunting club activities) on the dynamics of the bear population.

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STUDY AREAS

Location

We conducted research on 2 study areas within the Okefenokee-Osceola ecosystem in southeast Georgia and north central Florida (Fig. 2). This ecosystem includes the ONWR, Osceola NF, and adjacent private lands, and is centered approximately at 30° 40’ north latitude and 82º 30’ west longitude. At 6,147 km^2, this is the second largest ecosystem supporting black bears in the southeastern coastal plain (Wooding et al. 1994). The northern study area, which we refer to as the Okefenokee study area, is located in parts of Charlton, Clinch, and Ware counties, Georgia, on the northwestern corner of the ONWR. Approximately 40 km to the south, the second study area (Osceola study area) is located in Baker and Columbia counties, Florida, and situated on the western boundary of the Pinhook Swamp Unit of the Osceola NF.

The ONWR encompasses approximately 1,580 km^2 of swamp and adjacent pinelands, with 1,416 km^2 designated as Wilderness. The refuge includes >90% of the swamp. The 511-km^2 Okefenokee study area included the swamp and islands (Craven’s Hammock, Craven’s Island, Hickory Hammock, and Pine Island) within ONWR and the adjacent private lands to the northwest of the Refuge (Fig. 3).

Private lands within this study area were predominately managed pine plantations owned by Jefferson Smurfit and Container Corporation, and Rayonier. The nearest major roadways were US 84 to the north, US 1 and 23 to the east, FL SR 2 to the south, and US 441 to the west. Nearby population centers were the cities of Waycross to the north, and Folkston to the east of the refuge.

Osceola NF consists of 2 disjunctive tracts that occupy approximately 798 km^2 in portions of Baker and Columbia counties in north central Florida. The 366-km^2 Osceola study area included the southwest portion of Pinhook Swamp, the north portion of Big

Gum Swamp, the northeast portion of Impassable Bay, and adjacent private lands (Fig. 4). Private lands within the study area were predominately managed pine plantations owned by Bankers Trust, Jefferson Smurfit and Container Corporation, and Rayonier. The nearest major roadways were SR 2 to the north, SR 127 to the east, US 90 to the south, and US 441 to the west. The closest areas of urban development were Lake City to the southwest, and McClenny to the southeast.

Climate

The climate in north Florida and south Georgia is subtropical, characterized by cool, dry winters and hot, wet summers (Howell 1984). In the fall and winter, high-pressure cells over Bermuda prevent the formation of thunderstorms, but in the spring these high-pressure cells begin to weaken. The resulting convective rains drop the majority of the average annual 137-cm precipitation during afternoon thunderstorms, primarily from June through September (Chen and Gerber 1990, Howell 1984). The average annual temperature for the region is 20°C and ranges from an average minimum of 13°C to an average maximum of 27°C. Long-term extremes range from -16°C to 39°C (Henry et al. 1994).

Topography and Geology

The Okefenokee Swamp lies in the Coastal Terraces Province of the Atlantic Coastal Plain, a region characterized by a series of relatively flat step-like terraces that lie parallel to the coast. Each layer is successively lower in elevation and bounded on the east by sandy ridges, formed in the late Pliocene and the early Pleistocene by the retreating shoreline as the sea level dropped. The Okefenokee Swamp developed on a terrace 30–45 m above present sea level. This terrace was covered by relatively impermeable sandy clays and clayey sands of a former lagoonal salt marsh trapped behind a broad sand ridge to the east, called Trail Ridge, and a lesser ridge to the south (Cohen et al. 1984). As surface water accumulated, the basin became increasingly inundated and hydrophytic plant communities were established (Loftin et al. 2000). Peat formed in depressions and eventually covered some of the old shoreline features. In places this layer of peat was so thick that the trees are rooted entirely in it, creating free-floating islands that sway when walked on or disturbed (Duever and Riopelle 1983). These ‘floating’ trees inspired Native Americans to call it ‘Okefenokee’ or ‘land of the quaking earth' (Cohen et al. 1984). Eventually, the Okefenokee Swamp became a peat-forming bog characterized by forested wetlands, marshes, and open water maintained by periodic fires and drought. Although the elevational gradient in Okefenokee is slight, small changes in wetland systems greatly increase vegetational and faunal diversity (Wigley and Lancia 1998).

The surface geology of the upland watershed, which surrounds the Okefenokee Swamp, is characterized by intensively leached sandy soils that have a higher clay content with increasing depth (Laerm and Freeman 1986). Soils in this region, formed from marine sediments deposited during the Pleistocene and Holocene epochs, are typically acidic and poor in nutrients.

Lacking the significant terraces and ridges that surround the Okefenokee basin, Osceola NF is composed of a mosaic of smaller swamps and bayheads interspersed within wet pine flatwoods. Elevations within Osceola NF range from 115–125 m above present sea level. Soils are primarily Mascotte-Oscilla-Surrency associations (U. S. Department of Agriculture 1997). At 24,291 ha, Pinhook Swamp is the largest swamp in the Osceola study area. Several lesser-known swamps include Big Gum Swamp, Impassible Bay, and Sandlin Bay. These smaller swamps have substrate, hydrology, prairies, and peat formations similar to the Okefenokee Swamp, but lack the distinctive boundaries and depth of peat to form free-floating tree islands.

Hydrology

The Okefenokee Swamp is one of the largest freshwater wetlands in the United States. Water input to the swamp primarily occurs through precipitation, but springs and stream runoff from the higher lands to the northwest add to the volume (Duever 1982). Many tributaries and small creeks throughout the private lands surrounding the refuge also contribute to water input. Approximately 85% of the outflow drains to the west, creating the Suwannee River, which empties into the Gulf of Mexico (Loftin et al. 2000). The remainder of the water flowing out of the swamp is carried southeast to the Atlantic by the St. Mary's River (Rykiel 1977). Construction of the Suwannee River Sill, completed in 1962, resulted in a significant rise in water levels which, in turn, markedly affected vegetation distribution, nutrient cycling, and peat accumulation (Yin and Brook 1992).

Like the Okefenokee, the primary source of water into Osceola NF occurs through precipitation. With no ridges and little topographic relief, there are few channeled streams in this area; therefore, most drainage occurs as sheet water. The largest contiguous swamp in Osceola NF is the 243-km^2 Pinhook Swamp. Only a broken sandy ridge, the Blue Ridge, separates Pinhook Swamp from the Okefenokee Swamp. Florida SR 2 and Georgia Southern & Florida Railroad were built on this small interfluve, which is <5 feet high in most places (Thompson 1995). A breech in this ridge, called Breakfast Branch, allows Pinhook to drain north, where it flows into the Okefenokee. Due to this connection, Pinhook Swamp is often called the southern extremity of the Okefenokee Swamp, and part of the headwaters of the Suwannee and St. Mary's rivers. The most well developed channel is Suwannee Creek where it drops from 120 m to 95 m above sea level in 3 km. Little Creek, the only other creek on the Osceola study area, flows west into the Suwannee River. Runoff through these smaller bays and swamps eventually reaches either the Suwannee or St. Mary's rivers by creeks or branches outside the study area.

Fauna

The ONWR and Osceola NF support over 232 bird, 66 reptile, 48 mammal, 36 fish, and 37 amphibian species (Laerm et al. 1980). The vertebrate diversity of this wetland system is greater than in any area of similar size in the adjacent Southeast. This high diversity is a result of the dynamic and complex landscape mosaic (Meyers and Odum 1991) and because many species reach the geographical limit of their ranges at or near the area (Laerm et al. 1980). Large mammal species include black bear, feral hogs (*Sus scrofa*) and white-tailed deer. Small mammal species include eastern cottontail (*Sylvilagus floridanus*), marsh rabbit (*Sylvilagus palustris*), and gray squirrel (*Sciurus carolinensis*). Other common mammals include bobcat (*Felis rufus*), gray fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), opossum (*Didelphis virginianus*), raccoon (*Procyon lotor*), river otter (*Lutra canadensis*), and striped skunk (*Mephitis mephitis*). Common upland game birds are bobwhite quail (*Colinus virginianus*), mourning dove (*Zenaida macroura*), and wild turkey (*Meleagris gallopavo*). The gopher tortoise (*Gopherus polyphemus*), eastern indigo snake (*Drymarchon corais*), red cockaded woodpecker (*Picoides borealis*), wood stork (*Mycteria americana*), and gray bat (*Myotis *grisescens*) are resident species recognized as endangered by the USFWS.

Flora

The Okefenokee Swamp is a basin composed of a wide diversity of habitat types. Pure to mixed stands of bay, blackgum (*Nyssa sylvatica*), and cypress (*Taxodium* spp.) forests, shrub swamps, prairies, and open water constitute the 1,360 km^2 of wetland habitats in the ONWR. The drier upland areas on the remote islands and surrounding the swamp basin are comprised of large expanses of forested pinelands interspersed with smaller bayheads and cypress domes. The surrounding private lands are predominantly managed as industrial slash pine (*Pinus elliotti*) plantations. Within ONWR, approximately 134 km^2 of upland habitat are managed for the protection and restoration of longleaf pine (*Pinus palustris*) and wiregrass (*Aristida stricta*) communities (U. S. Fish and Wildlife Service 2001).

In the Osceola study area, cypress, blackgum, and fetterbush (*Lyonia lucida*) dominated the larger swamps (Wooding and Hardinsky 1994). Pine flatwoods were dominated by slash pine, saw palmetto (*Sereona repens*), and gallberries (*Ilex coriacea* and *I. glabra*; Avers and Bracy 1973). As with the Okefenokee study area, small cypress swamps and bayheads were distributed throughout the pine flatwoods habitats.

History and Land Use

Although the region is considered 'wild,' neither the uplands nor the swamps are pristine. Historically, the primary use of land in the Okefenokee was timber production. In 1889, the Suwannee Canal Company purchased 964 km^2 of the Okefenokee Swamp from the State of Georgia (McQueen and Mizell 1926). After a failed attempt at draining portions of the swamp to facilitate agricultural production, the company began harvesting cypress. Before declaring bankruptcy in 1897, the Suwannee Canal Company harvested >7 million board feet of cypress timber (Izlar 1984). Timber harvesting resumed in 1909 when the Hebard Cypress Company constructed several railroad trams that allowed access to the swamp interior. By the time logging in the swamp ceased in 1927, approximately 425 million board feet of timber had been harvested (Hopkins 1947). From 1890–1927, enough mature cypress was removed that approximately 40% of the virgin old growth area had been replaced by younger, second growth (Hamilton 1982). In 1936, the USFWS purchased the Hebard Cypress Company's holdings, creating the

ONWR in 1937. Although logging within the refuge has ceased, the majority of land adjacent to and surrounding the swamp is now owned and intensively managed by large timber companies. These private holdings are typically managed for slash pine production on a 20–25 year rotation. In the more remote areas of the interior refuge, virgin cypress forests remain; the oldest trees have been aged at >600 years (Duever and Ripolle 1983).

In addition to forestry, honey production is an important agricultural commodity within the region (National Agricultural Statistics Service, U. S. Department of Agriculture, unpublished report). Beeyards were located on private lands outside of ONWR with surrounding areas leased for bee grazing. Beeyard plots were designated and leased to beekeepers by contract on a yearly basis. Other agricultural commodities included corn, cotton, soybeans, tobacco, and cattle (Georgia Agricultural Statistics Service, U. S. Department of Agriculture, unpublished report).

Hunting is the most common recreational use of private lands immediately outside ONWR. All private land holdings within the Okefenokee study area were leased to 3 hunt clubs. The bear hunting season consisted of 3, 2-day hunts occurring on the last Friday and Saturday of September and the first 2 Fridays and Saturdays in October. Beginning in 1998, the Georgia Department of Natural Resources (Georgia DNR) permitted a 3-day hunt in the Dixon Memorial Forest (adjacent to the ONWR on the north) during the first week of December. Hunting regulations stipulated that 1 bear may be harvested per licensed hunter per year by still-hunting (firearms and archery) or with the aid of dogs; hunting over bait was prohibited. Although hunting pressure was significant during the relatively short season, most human presence on the Okefenokee study area was during the year-round dog chase season when baiting was allowed. On the Okefenokee study area, hunt club members chased bears with dogs approximately 3 days per week from April to mid-September. The only times that bears typically were not being chased was during the denning season, the 2-week period immediately prior to the hunt season when baiting was prohibited, and the weekdays between the 3 consecutive hunt weekends. Access into ONWR was restricted to designated entrances and canoe trails, and hunting of any kind was prohibited.

The Osceola area was originally occupied by the Timucuan Indians, as noted in 1535 by Hernando de Soto during his travels through the area that is now Lake City, Florida. During the early 1800s, Seminole Indians occupied much of the area until moving to an area further south (U. S. Department of Agriculture 1997). Throughout the mid- to late-1800s much of the prosperity and growth in the Osceola area was associated with cotton production (U. S. Department of Agriculture 1997). By 1910, only 14% of the land in the region was altered and there were <20 people per square mile (Harper 1914). In addition to logging, turpentine extraction and grazing were important industries. As was the case in Georgia, the majority of land within the Osceola study area, including Osceola NF, was currently managed for slash pine production. Beekeeping seems to have replaced the turpentine industry and there is still some grazing on the western edge of the study area.

Access to the private lands in the Osceola area was regulated by timber companies and was restricted to employees and members of leased hunt clubs. The main parcel of Osceola NF had free access via public roads, but because the Pinhook Swamp Unit was closed to vehicular traffic. Because the bear season was closed in Florida in 1994, white-tailed deer and hogs were the primary prey for big game hunters in the Osceola study area.

MATERIALS AND METHODS

Study Design

To compare the effects of differing management practices on the dynamics of the bear population, our approach was to use 2 study areas where hunting regulations and habitat management conditions contrasted. In that way, bear population demographics and habitat use could be compared across treatments, while controlling for extraneous variables such as weather. The 2 areas were the Okefenokee study area and the Osceola study area, as described above. The Okefenokee study area included the northwest portion of ONWR and adjacent private lands. Those private lands consisted of industrial timberlands, a state forest, and a state wildlife management area. Hunting was allowed in the portion of this study area outside the NWR boundaries. The Osceola study area was situated along the southern boundary of ONWR, again with a portion of the study area on public land (Osceola NF) and the other portion on private land. Being in Florida, bear hunting was not allowed on this study area. Thus, our study design enabled us to make demographic comparisons between areas with and without hunting. Additionally, the wide array of habitat management practices, from industrial timberlands, to a National Forest, to a Wilderness Area (portions of OWNR), enabled us to compare bear population characteristics and habitat use relationships with different habitat management practices. With this design, our goal was to determine habitat needs based on a range of occupied habitats including the swamp itself and adjacent timberlands (both public and private).

Trapping and Handling

The logistical challenges of the research prevented simultaneous sampling of both units the first year of the project. Consequently, we trapped the Okefenokee study area beginning in 1995, and began field work on the Osceola study area in 1996. Black bears were trapped from early June through late September from 1995–1998 and 1996–1998 on the Okefenokee and Osceola study areas, respectively. We conducted some limited trapping on more remote locations within ONWR during late October and early November 1995–1997. All bears were captured using Aldrich spring-activated foot snares (Aldrich Animal Trap Company, Clallam Bay, Washington). Because inaccessible and impenetrable habitat precluded random trap placement, trapsites were established according to habitat type, known bear travel routes, and bear sign.

We primarily used 3 trapping techniques to capture bears. Standard trail sets baited with dry corn placed in hanging plastic bottles were used as an initial attempt to catch bears at trapsites (Clark 1991, Brandenburg 1996). Bears were lured to those trapsites with artificial raspberry flavoring (Mother Murphy’s, Greensboro, North Carolina). Blind sets (i.e., traps without bait) were used to capture bears that had learned to steal baits without being captured. Lastly, dirt-hole sets were used when blind sets failed to capture trap-wary bears. A dirt-hole set consisted of a snare with the foot-loop placed atop a freshly dug hole and camouflaged with discarded trash. We used trees to secure snares, but we used mobile home anchors (123 cm long with a 10-cm auger) to secure snares when trees were unavailable.

We checked traps 1 to 2 times daily, depending on site conditions. In well-shaded areas, traps were usually checked by 1100. We checked trapsites without the cover of shade or in close proximity to human activity by 0800. Those traps were deactivated during the day and reactivated at dusk to prevent bears from being captured in direct sunlight or in full view of the public.

We immobilized captured bears with a 2:1 mixture of ketamine hydrochloride (Ketaset, Burns Veterinary Supply Incorporated, Farmers Branch, Texas) and xylazine hydrochloride (Rompun, Haver-Lockhart Incorporated, Shawnee, Kansas). Immobilization drug was intramuscularly administered with a push pole at a dosage of 4.4 mg (1 ml/ 22.7 kg) of Ketaset and 2.2 mg (1 ml/ 45.5 kg) of Rompun per kg of estimated body mass. After immobilization, we applied a wetting agent (Akwa Tears, Akorn Incorporated, Abita Springs, Louisiana) to the bears' eyes to prevent desiccation. A blindfold was then placed over the eyes to protect them from debris and to minimize visual stimuli. We monitored body temperature, pulse, and respiration throughout each immobilization.

We tattooed a permanent identification number on the inside upper lip of each bear using 0.8-cm numeric digits (Nasco, Fort Atkinson, Wisconsin) and animal tattoo ink (Ketchum Manufacturing, Ottawa, Canada). Numbered ear tags, corresponding to individual tattoo identification numbers, were placed in both ears of each bear. Male bears received a rectangular metal tag (Hasco Tag Company, Dayton, Kentucky) in the right ear and a plastic round colored tag in the left ear. Female bears received the same types of tags but they were placed in opposite ears. This method of tagging enabled hunters to identify male and female bears that were seen during the year-round dog chase season.

Each female bear >1 year-old received a motion-sensitive radio collar (Telonics Incorporated, Mesa, Arizona and Lotek Engineering Incorporated, Ontario, Canada). A select number of male bears on the Okefenokee study areas were radiocollared for an analysis of beeyard damage. We equipped each collar with a 12.5-cm wide by 0.4-cm thick leather spacer that served as a breakaway device (Hellgren et al. 1988). To prolong their durability, all spacers were soaked in vegetable oil for at least 1 month before being placed on a collar. We extracted a first upper premolar tooth for aging by cementum annuli analysis (Willey 1974). Sectioning, staining, and aging of teeth were conducted by Mattson Laboratories (Milltown, Montana). We used a chi-square test for equal proportions to determine whether sex ratios differed from 1:1. Sex ratios between study areas were compared with a goodness-of-fit test. Bears were weighed with a spring scale and standard morphological measurements were recorded. We tested for differences in weights by study area, gender, and year using analysis of covariance with age as the covariate.

Information concerning the general description, reproductive status, tooth wear, and physical appearance was recorded for all bears. We collected tissue and hair samples from each bear to be used for microsatellite analysis. Lastly, we administered yohimbine hydrochloride (Lloyd Laboratories, Shenandoah, Iowa), an antagonist for xylazine hydrochloride, through the sublingual vein at a dosage of 0.2 mg/kg of body mass.

Estimation of Population Size

We used a combination of methods to estimate black bear population size on the Okefenokee and Osceola study areas (Fig. 5). A method to estimate bear population size based on DNA extracted from hair collected from baited, barbed-wire hair traps was developed after we initiated the study in 1995 (Woods et al. 1996, 1999; Taberlet et al. 1997; Mowat and Strobeck 2000). If correctly genotyped, that DNA can be used to develop a mark-recapture estimate of population size. The technique has advantages over traditional live trapping because it is less affected by capture bias, closed estimators can be used, and sample sizes are often improved. Consequently, we used the barbed-wire hair traps to estimate population size on both study areas during 1999. We calculated within-year estimates with several closed multiple mark-recapture models described by Otis et al (1978), White et al. (1982), and Chao (1987, 1988, 1989), using Program CAPTURE (Rexstad and Burnham 1992). Several pooling configurations of the 1999 hair trap sessions were considered (Figs. 6 and 7) We used chi-square goodness-of-fit tests within Program CAPTURE to identify variation in capture probabilities as a result of time, behavior, and individual heterogeneity effects (Otis et al. 1978). Those test results were then used to aid in selecting the most appropriate model for the different pooling configurations of the 1999 hair data. Additionally, we tested for equal catchability by comparing observed capture frequencies to a zero-truncated Poisson distribution (Caughley 1977).

Additionally, we used live trapping data from 1995–1998, along with hair-trapping data for 1999, to estimate population size with open Jolly-Seber models (Jolly 1965, Seber 1965) in Program JOLLY (Pollock et al. 1990). We evaluated models A (capture and survival probabilities vary), A’ (deaths only model), B (constant survival), and D (constant capture and survival rates). Program JOLLY uses chi-square analyses to identify variation in capture probabilities due to trap heterogeneity or trap response. Likewise, these goodness-of-fit tests were used to aid in the selection of appropriate models.

We collected hair samples from free-ranging bears at barbed-wire hair traps on both study areas. These baited “enclosures” consisted of a single strand of barbed wire (2-strand wire, 4 points, 7.5-cm spacing between barbs) attached to trees to form a polygon (Fig. 8). Wire was affixed to the outside of perimeter trees using 2.5-cm aluminum fence staples and tensioned by hand using fencing tools. Baits consisted of plastic bottles containing dried corn, suspended from a wire in the center of the enclosure.

Bear visits to hair traps typically resulted in multiple hair samples being left on barbs. Although all samples were individually collected, only samples with ≥5 hairs were good candidates for microsatellite analysis (T. King, U. S. Geological Survey, personal communication). Of those samples, 1 was chosen for potential analysis. Based on simulation results of live-capture data from 1998, we then randomly chose 8 hair samples from each of the trapping periods on each of the 2 study areas to provide population estimates with coefficients of variation ≤0.25. The method of uniform random sampling was chosen to ensure equal sampling effort from every trapping period (K. Pollock, N. C. State University, personal communication).

Removal of hair roots and preparation for DNA extraction was performed at the University of Tennessee. We clipped approximately 0.6 cm of the root end of each hair and placed all roots from each sample into a 1.5-ml centrifuge tube. DNA extractions, replication by polymerase chain reaction (PCR), and microsatellite analysis were performed at the U. S. Geological Survey Aquatic Ecology Laboratory at the Leetown Science Center, Kearneysville, West Virginia (see Appendix 1 for details of genetic analyses). Hair samples selected for analysis were identified based on 8 individual microsatellite loci (G1A, G1D, G10B, and G10L [Paetkau and Strobeck 1994], and G10C, G10M, G10P, and G10X [Paetkau at al. 1995]).

One of the primary assumptions of mark-recapture estimators is that marks are not lost or overlooked (Pollock 1990). Although we assumed matching hair samples represented a recaptured animal, it was possible that different individuals could share identical genotypes at the 8 loci examined (Woods et al. 1999, Mills et al. 2000). Factors influencing the likelihood of hair samples having an identical genotype include the number of loci examined (Woods et al. 1999) and the degree of genetic variability present in the population (Paetkau et al. 1998).

To assess the variability of the loci examined, we estimated the probability that 2 individuals drawn at random from a population would share an observed genotype. That statistic, referred to as the probability of identity (PI), is defined as the proportion of the population possessing genotypes that cannot be distinguished from one other individual (Mills et al. 2000). We also used a computation for PI that estimates a probability of identity among randomly sampled siblings (PI*sibs*; Taberlet and Luikart 1999). That statistic provides a more conservative means of identifying how many loci are needed to obtain a sufficiently low PI, thereby increasing the likelihood that all individuals are correctly identified. When calculating PI*sibs*, however, it is necessary to assume that allele genotypes are in Hardy-Weinberg equilibrium (Taberlet and Luikart 1999, Klug and Cummings 1991). Assuming the conditions of Hardy-Weinberg proportions are met, the calculation of PI*sibs* serves as a statistical basis for genetic match declarations among individuals.

Two additional tests, developed by Woods et al. (1999), calculate the probabilities that a parent or offspring of an individual ($P_{\text{par-offs}}$) or their sibling (P_{sib}) would have the same genotype. As a result of the close genetic relations between siblings, the sibling match test (P_{sib}) is the most conservative of all tests described. We used the sibling match test to identify 8-locus genotypes that were potentially shared between >1 individual. Genotypes were accepted as unique when $P_{\text{sib}} < 0.05$. Hair samples failing to meet that criterion were excluded from analysis (Woods et al. 1999, Mowat and Strobeck 2000).

We also used the linkage disequilibrium test in Program GENEPOP 3.1 (Raymond and Rousset 1995) to test the null hypothesis that genotypes at 1 locus are independent from genotypes at another. Rejection of that hypothesis would indicate some non-random association between alleles of different loci (i.e., linkage disequilibrium; Avise 1994). Because the 8 microsatellite loci used in our analysis have been found to be independent (Paetkau and Strobeck 1994, Paetkau et al. 1994), any significant linkage observed among loci pairs may indicate sampling bias, non-random mating within the population, or stochastic processes which affect population genetics (T. L. King, U. S. Geological Survey, personal communication).

To investigate the likelihood of inbreeding in the Okefenokee-Osceola population, we used the Hardy-Weinberg probability test in Program GENEPOP 3.1 (Raymond and Rousset 1995). We performed individual tests at each locus for every 8-locus genotype that was identified (Paetkau et al. 1998, Boersen 2000). Rejection of H_o would imply a likelihood of inbreeding or other form of non-random mating in the population.

To estimate population density, a determination of study area size was necessary. We delineated respective study areas by circumscribing each of the 1999 hair trap sites with a circle, the area of which was equivalent to the average home range estimate for female bears. Those home ranges were estimated using the 95% Minimum Convex Polygon estimator in ArcView® GIS (Environmental Systems Research Institute, Redlands, California). We limited the analysis to bears with ≥30 locations collected from 1995–1999 and 1996–1999 on the Okefenokee and Osceola study areas, respectively. Furthermore, telemetry data were restricted to locations with collection dates that coincided with the months of the hair-trapping season (June to September, 1999). We calculated average density estimates for black bears on the Okefenokee and Osceola study areas by dividing the population estimates by these study areas sizes. Dividing the upper and lower limits of the population estimates by the sizes of the study areas produced 95% confidence intervals for each density estimate.

Radio Telemetry

During the 1995–1998 trapping seasons we fitted selected bears with radio collars equipped with a mortality sensor (Telonics Incorporated, Mesa, Arizona and Advanced Telemetry Systems, Isanti, Minnesota). We located radiocollared bears from the ground using a model TR-4 receiver (Telonics Incorporated, Mesa, Arizona) and a 5-element, vehicular roof-mounted antenna (Wildlife Materials, Carbondale, Illinois). Aerial locations were collected from a Cessna 172 fixed-wing aircraft using a TR-4 receiver and a toggle switch that enabled us to change reception between H-antennae (Telonics Incorporated, Mesa, Arizona) mounted to each wing strut.

Telemetry locations obtained from the ground were determined by triangulation using the "loudest signal method" (Springer 1979, Mech 1983). Bear locations were calculated from $\geq$3 azimuths that were between 45º and 135º apart and collected within 20 min. Ground telemetry data were plotted on 1:24,000 U. S. Geological Survey (USGS) topographic maps at the time of collection. Aerial locations were obtained by flying increasingly smaller circles over radiocollared bears until we assumed individuals to be directly under the plane. Locations were then recorded using a global positioning system (GPS; Magellan GPS Systems, Osborne Park, Australia). All GPS locations were recorded in Universal Transverse Mercator (UTM) coordinates.

Telemetry Error

We estimated telemetry error during this study by placing test collars throughout each study area in all habitat types that were used by bears. Test collars were located by ground and aerial telemetry using methods identical to those described above. In all instances, locations of test collars were unknown to the recorder. Telemetry error was obtained by calculating the distance between the estimated location and the actual location (using a GPS; Clark 1991). In addition to test collars, we also incorporated locational data from dropped radio collars and known den sites into our telemetry error analysis. In those cases, error was determined by calculating the distance between the actual location and the first recorded telemetry location.

Survival

We monitored radiocollared bears 1–4 times per week to obtain locational data and to estimate survival. We visually located any radio collar that switched to mortality mode to determine whether death had occurred and its cause. We used the Kaplan-Meier staggered entry procedure (Pollock et al. 1989) to estimate annual survival of radiocollared female bears on both study areas. Additionally, we estimated male survival on the Okefenokee study area from 1996–1999. The estimated survival function was calculated as

$$\hat{S}(t) = \prod \left(\frac{1 - d_j}{r_j} \right), \text{ where}$$

$$\frac{j}{a_j} < t,$$

$\hat{S}$ is the probability of survival, d_j is the number of deaths at time a_j, r_j is the number of animals at risk at time a_j, a_j is a particular time of death, and t is the time interval (Pollock et al. 1989). Estimates of variance (var) were calculated as

$$\text{var}\left[\hat{S}(t)\right] = \frac{\left[\hat{S}(t)\right]^2 \left[1 - S(t)\right]}{r(t)}.$$

Assumptions of the Kaplan-Meier staggered entry procedure are (Pollock et al. 1989): 1) all bears were sampled randomly, 2) survival times were independent for individual bears, 3) capturing or radiocollaring bears did not influence future survival, 4) censoring mechanisms were random, and 5) survival functions for newly radiomarked bears were the same for previously marked bears.

We used the log-rank test (Pollock et al. 1989) to compare overall survival rates by sex and study area. To determine the effects of hunting on Okefenokee bears, we recalculated annual survival rates by treating harvested bears as censored (Martorello 1998).

The bear-hunting season for counties surrounding ONWR occurred on the last weekend of September and first 2 weekends of October (6 total days) every year of this study. We operated a mobile bear check station so that bears harvested on the Okefenokee study area could be legally recorded and issued a state harvest tag. This allowed us to document any hunting mortalities of radiocollared bears on or in close proximity to the study area within hours of harvest. Physical data included tag number, sex, weight, general condition, a tooth for aging if the bear was not tagged, and method of harvest (i.e., with dogs or still hunting). If bears were harvested with the aid of dogs, we also documented weapon type, number of hunters in the party, number of dogs used, and length and duration of the chase. We used ANOVA (PROC GLM, SAS Institute Inc.,

1985) to compare weights by sex and year. Differences in annual sex ratios were tested for using a chi-square test for equal proportions.

Additionally, radiocollared bears on the Okefenokee study area were monitored 1 day prior to and during each day of the bear season to determine the availability of those bears to harvest. Telemetered bears were monitored using a fixed-wing aircraft and from the ground. On the Okefenokee study area, Perimeter Road lies directly adjacent to the ONWR boundary and travels the length of the study area. Radiocollared bears located on the western side of Perimeter Road were classified as available to harvest with the aid of dogs. We classified bears located on private lands on the eastern side of Perimeter Road as available to harvest by still hunting because hunters rarely released dogs in roadless areas adjacent to ONWR. All radiocollared bears located within ONWR were classified as unavailable for harvest. We used the Heisey-Fuller technique to calculate daily survival rates during the hunting season (Heisey and Fuller 1985).

Reproduction and Denning

We evaluated denning sites and habitats from radiocollared bears on both study areas during 1995–1998. Den sites of radiocollared bears were first located by fixed-wing aircraft, and then visited on foot using ground telemetry. Den-site characteristics (e.g., location, den type, habitat type) were recorded for all denning bears. Den entry dates were defined as the midpoint between the last recorded movement and the first location in the den. Den emergence was assumed to be the midpoint between the last recorded den location and the first location away from the den. A Kruskal-Wallis test with reproductive status as the main effect was used to test for differences in mean den entry and emergence dates and length of denning period among females. We used the Wilcoxon rank sum test to compare den entry and exit dates and denning duration between sexes and study areas.

We determined the reproductive status of radiocollared females by visual observation or listening for young at den sites. Den visits were made during the first 6 weeks following den entry. Our primary objective in making those visits was to determine whether females had produced cubs. Upon den emergence we approached family groups using ground telemetry and determined litter size by visual observation. Bears were not handled in dens to minimize chances of cub abandonment.

Population Modeling

We used a population model (RISKMAN, version 1.5.413; Ontario Ministry of Natural Resources, Toronto, Ontario, Canada) to estimate population growth and sustainable yield. This individually-based model required estimates of cub survival; litter survival; subadult male and female survival; adult male and female survival; litter production rate; and the probability of producing 1-, 2-, 3-, or 4-cub litters. Litter survival was the probability that at least 1 cub in a litter survived. Litter production rates were the probability that females in reproductive condition (i.e., without the previous year's cubs) would produce a litter. We used the covariance option in RISKMAN to simulate non-independence of parameter variances. For example, environmental variation likely would affect both adult and subadult survival during a single year and this model option incorporated such covariances into the stochastic trials. We did not include density effects in the simulations.

We used the 1998 standing age distribution as starting conditions based on the trapped sample of bears during that and previous years, with the assumption that previously captured bears were still present in the population if they were not known to be dead. We pooled data across years on each study area to estimate natural and harvest mortality rates and variances by age class for use in the growth simulations. For these and other rate parameters, we grouped data into age class strata (e.g., cubs, subadults, adults). Population size was estimated based on our mark-recapture analyses.

Survival rates and variances for the simulations were based on Kaplain-Meyer estimates of all non-hunting mortalities (e.g., natural mortalities, road kills). The number of bears harvested and their ages and sex were used to generate a hunter selectivity function for harvest simulations for the Okefenokee study area. We evaluated the effects of varying levels of harvest for a 10-year period beginning in 1999, based on 1000 stochastic simulations.

Food Habits

We analyzed scats collected between June 1995 and December 1999 to identify major food items in the annual and seasonal diets of bears. Scats were analyzed whenever we encountered them during daily research activities. Ocular estimates of frequency of occurrence and percent volume were determined for each food item (Martin et al. 1946, Allen and Pelton 1998). Items comprising <1% volume were considered trace amounts. Food items were identified to the lowest possible taxon. On the Okefenokee study area, stomach contents of harvested bears also were examined whenever possible.

Frequency of occurrence for individual food items was calculated by summing the number of scats in which individual food items were identified, and dividing that value by the total number of scats analyzed. Percent volume was determined by summing the percent value from each scat for each food item, and dividing the item total by the overall percent volume of all food items. Food items were grouped into 6 categories: agricultural crops, tree fruit, shrub/vine fruit, animal matter, vegetation, and debris. Seasons were determined by major shifts in bear food habits: winter – 1 January to 31 April; spring – 1 May to 30 June; summer – 1 July to 30 September; and fall – 1 October to 31 December.

Home Range Analysis

We used the 95% fixed kernel method (Worton 1989) to estimate seasonal, annual, and overall home ranges for bears on both study areas. Because the kernel method is a nonparametric estimator, no assumptions about underlying probability distributions are required (Worton 1989). In addition, the kernel method calculates a home range utilization distribution that estimates probability of use within the area used by each animal. Thus, the kernel estimator will assign a higher probability of use to areas containing a higher concentration of radio locations, and a lower probability to areas containing fewer locations (Worton 1989). As a result, the effect of outliers is minimal and areas of concentrated activity can be identified. All 95% fixed kernel estimates were calculated using the Animal Movement Extension (Hooge and Eichenlaub 1997) in ArcView® Geographic Information System.

Annual home ranges were calculated for all bears with $\geq$40 radiolocations that were monitored for at least 6 months during the active season (late April to December). During winter months, we incorporated only the first recorded den location into annual home range estimates. We estimated seasonal home ranges for all bears with $\geq$30 locations collected within the spring, summer, or fall seasons. Winter home ranges were not estimated because sample sizes were small. After testing for normality, we used the Wilcoxon rank sum test to compare overall home range sizes within and between study areas by sex and age class. We tested for annual variation was tested for by transforming data by $\log_{10}(x)$ and using an analysis of variance (ANOVA). The transformed data also were used to compare overall annual home range sizes among females by reproductive status (with cubs versus solitary). Due to small sample sizes, we used the nonparametric Wilcoxon signed rank test (Snedecor and Cochran 1980) for paired comparisons between consecutive years and seasons.

Movement Patterns and Microhabitat Use

We evaluated fine-scale habitat use on the Osceola study area by observing movement patterns produced by collecting hourly radiolocations of selected bears during 2- to 23-hour sessions. Telemetry data were analyzed using the Animal Movement Analyst extension (Hooge and Eichenlaub 1997) to ArcView® GIS. At each location along the path, we classified the animals as active or inactive as determined by changes in signal amplitude (Kenward 1987, Mech 1983, and White and Garrott 1986).

Following Spitz (1988), an analysis of the movement paths from each telemetry session revealed 4 basic patterns: 1) Resting; bears were inactive and did not move, 2) Foraging; bears were active but movements were localized, 3) Searching; bears were active and movements were short and directional, and 4) Traveling; bears were active and movements were long. Criteria for interpreting the activity patterns were used to categorize the paths into 1 of 4 basic patterns:

Rest sites: A cluster of points having an active/inactive ratio of <50% were labeled Rest sites. In most cases, the distance between each point was less than the telemetry error, so the animal may not have actually moved between consecutive locations. In some cases, distances of $\leq$150 m were considered rest sites based on the activity ratio.

Forage site: We used the distance moved between each location, time elapsed, path shape, and the activity ratio to determine whether a cluster of locations was placed in the Forage category. For the area to be considered a Foraging site, the ratio of activity for a cluster of locations had to be ≥50% active, distances between consecutive active locations $\leq$100 m , and intervening movements had to be 100–400m with direction changes >90°.

Search activity: An animal was considered engaged in a Search activity if its movement path was directional (direction changes less than 90°) and it traveled 100 to 700 m between locations. Within this pattern, the animals were usually active for all location estimates, but occasionally an animal would be inactive at a location along the path for a short period followed by a movement of several hundred meters to the next location.

Travel activity: Movement classified as traveling was directional but the successive distances between locations were longer than those considered to be searching events. Most travel events did not last more than 1 h but, in some cases, it was apparent that the bear was traveling during several consecutive locations. Movements $\geq$700 m were labeled travel events.

Each movement path was overlaid onto a GIS coverage of vegetation structure or landscape (Suwannee River Water Management District 1995; Table 1). The radius of telemetry error was then used to buffer all location clusters fitting 1 of the 4 movement patterns (Fig. 9). We used that buffer area to “clip” the habitat types associated with that pattern from the digital coverages. We applied Johnson’s (1980) procedure for evaluating resource preference using a computer program developed by Pankratz (1994). This procedure tests for resource preference by using the differences between ranks, averaged across all individuals. By employing ranks, the measures of usage and availability do not have to be estimated exactly. We determined usage by summing the proportion of habitat types associated with each of the 4 buffered movement paths. The proportion of usage was calculated for each individual bear and across all categories. Availability was measured by extracting the habitat components from the 100% minimum convex polygon (MCP) ranges calculated with the hourly location data.

Seven of the 11 habitat types found on the study area received some use but occurred in very small proportions (6.6% combined) compared to the major habitat components (Table 2). Those lesser-used habitat types were removed and the data were analyzed using only the 4 major habitat types.

One company (Rayonier Inc.) within the study area possessed a current GIS coverage of stand age (updated in 1999). Rayonier lands comprised 40% (12,335 ha) of the study area. To evaluate use based on stand age, we used the buffered movement paths within available planted pine stands to generate similar statistics based on stand age. Stand age was grouped into 5-year increments. We also located and mapped the corn feeders for deer on the Osceola study area.

Additionally, we calculated the amount of time in hours that bears collectively spent within the various cover types present on the study area, which we termed "residence time". Using ArcView®, cover types along movement paths were clipped and chronologically organized. We then generated tables of frequency of movements between cover types (Proc FREQ; SAS Institute, Inc.1996). We also performed this procedure for stand age groups on Rayonier lands.

Macrohabitat Use

We used compositional analysis (Aebischer et. al 1993) to determine annual habitat use by black bears on the Okefenokee and Osceola study areas. This method was chosen because it fulfills several assumptions by which other techniques are constrained. The analysis described by Neu et al. (1974), for example, evaluates habitat use in terms of preference and avoidance of available habitats. Using this method, however, the proportional use of 1 habitat will inherently result in an apparent avoidance of another (Neu et al. 1974, Aebischer et al. 1993). Compositional analysis overcomes this problem by determining which habitats are used more or less than others, while considering the use of other habitats. In addition, compositional analysis takes the individual animal rather than the number of radio locations as the sampling unit. By doing so, the problem of serially correlated telemetry data is overcome and individual variation in habitat use is not masked (Aebischer et al. 1993).

We established 7 habitat types based on a digital map layer (30- x 30-meter resolution; Florida Gap Project) in ArcView®: gum/bay/cypress, loblolly bay, pine/oak, pine, swamp forest, shrub wetlands, and disturbed (Table 3, Figs. 10 and 11). Because pine/oak communities were primarily located on the interior islands of ONWR, and pine habitat was strictly managed for slash pine production on uplands, these 2 areas were separated for evaluation of habitat use. The disturbed classification was represented by open water, bare soil, and urban or agricultural lands. Those classifications were pooled because they contributed to <3% of the total area for each site and because of low use by bears.

In addition to various methods for habitat analysis, selection also can be analyzed at different levels within a hierarchical framework. Johnson (1980) characterized first-order selection as the overall range of a species within a geographic region. Second-order selection pertains to the location of a home range within the geographic range, and third-order selection refers to habitat use within the home range (Johnson 1980). We evaluated habitat use at the second and third-order levels for female bears on both study areas.

Although most analyses of habitat use rely on some discrete measure of habitat availability, methods for delineating available habitat at the second-order level vary between studies. One common technique has been to use home range boundaries to define areas of study. A drawback of using locational data, however, is that home range estimates will inherently include areas that have already been selected for. In those cases, an evaluation of habitat use likely would be biased towards preferred habitats (Clark 1991). For this analysis, we used trapsite locations as the initial basis for delineating study area boundaries. To define available habitat on each study area, we circumscribed each trapsite with a circle, the area of which was equal to the average annual home range estimate for female bears. Boundaries were defined by overlaying individual circles and connecting the outermost series of arcs using the BUFFER procedure in ArcView®GIS. Respective study area boundaries were created using only home range estimates for bears within each study area.

Apiary Depredation

We studied apiary depredation only on the Okefenokee study area; logistics prevented an intensive evaluation on both areas. Nuisance bears were defined as bears captured at trap sites set <100 m from a recently raided beeyard. Beeyard damage was monitored through daily research activities and by notification from local apiary owners. Nuisance bears at beeyards were captured with the same methods used to capture non-nuisance bears on our study area.

To determine whether bears within the study area were responding to beeyards, we first identified and collected GPS locations for all beeyards within the study area. Beeyard locations were then generated and plotted using ARC/Info® (Environmental Systems Research Institute., Redlands, California, USA). Bear telemetry locations and home ranges were overlaid on those beeyard coverages. We only used home ranges of bears that included $\geq$1 beeyard and were comprised of $\geq$45 locations within 1 year. Within each home range, we measured the distance between bear locations and the nearest beeyard; those distances were then compared using ANOVA with distances to random locations generated in ARC/Info®.

In addition to location, we recorded the owner, surrounding habitat, dimensions, number of beehives, number of bee supers, arrangement of hives, and fence characteristics for all beeyards in the Okefenokee study area. Fence characteristics were described in detail, including type and height of fence, type of wire, and number of electrified strands. Using GIS, we also determined the distances from beeyards to roads, bear bait sites, riparian zones, and swamp edges. We used ANOVA to compare characteristics of damaged and undamaged beeyards to identify factors that may have contributed to depredation.

We responded to all depredation reports within 24 h of the reported incident. Fence voltage, damage to the fence, damage to hives, and how the bear gained access were recorded for each site. If possible, depredating bears were captured, radiocollared, and released as described above. Working with the Georgia DNR, we evaluated a “three-strike” protocol for dealing with nuisance bears. The first strike occurred when a bear was captured at a raided beeyard for the first time. First-strike bears were physically examined, tagged, and released on-site as previously described. Bears that were subsequently captured at a damaged beeyard went though the same work-up process, but were relocated to a remote portion of the ONWR to minimize potential contact with humans. We monitored the movements of these second-strike bears to determine whether new home ranges were established or if they returned to their previous home ranges. If a second-strike bear continued to cause damages, that animal was euthanized (strike three).

Finally, we developed a mail survey of beekeepers in and around the study area to evaluate the extent of beeyard depredation (Appendix 2). Names and addresses were obtained from local and state beekeeper associations. The survey was mailed on 27 October 1997 and a reminder was mailed 2 weeks later. We mailed a second survey to non-respondents on 10 November 1997 and a final reminder was mailed on 15 December 1997.

RESULTS

Trapping and Handling

Sex and Age Structure.—Project personnel captured 205 different black bears (124M: 81F) 345 times (215M: 130F) from June 1995 to September 1998 (Table 4). During that time, 347 traps (Fig. 12) produced 6,425 trap nights resulting in 213 (137M: 76F) captures of 127 individual bears (76M: 51F) on the Okefenokee study area (Table 4, Appendices 3 and 4). On the Osceola study area, 296 traps (Fig. 13) were set for 5,111 trap nights from June to September, 1996–98. We captured 78 individual bears (48M: 30F) 132 (78M: 54F) times (Table 4, Appendices 5 and 6). Annual captures ranged from 33 (1996) to 78 (1995) and 39 (1996) to 48 (1997) on the Georgia and Florida study areas, respectively. Overall trapping success was 3.0%, or approximately 33 trapnights per capture (Table 4, Appendices 4 and 6).

The sex ratio of bears captured on the Okefenokee study area was 137M:76F, which differed from 1:1 ($\chi^2_{0.05}$ = 17.47, 1 df, P < 0.001). The sex ratio of Osceola captures (78M:54F) also differed from 1:1 ($\chi^2_{0.05}$ = 4.36, 1 df, P < 0.037). Annually, sex ratios of captured bears on Osceola never differed statistically from a 1:1 ratio, but Okefenokee captures favored males every year except 1996 (Table 5). The discrepancy in sex ratios was largely a product of the yearling age classes (Table 6; Fig. 14); the sex ratio among captured adults did not differ from 1:1 on the Georgia (58M:55F) or Florida (28M:30F) study areas (Table 6).

The oldest bears we captured were a 13-year-old female on Okefenokee and a 13-year-old male on Osceola (Fig. 15). Average age of Okefenokee bears was 4.3 years (n = 180, SE = 0.20); females were older than males (t = 3.71, df = 178, P = 0.0003), averaging 5.2 (n = 68, SE = 0.32) whereas males averaged 3.8 (n = 112, SE = 0.24) years (Table 7). Bears on Osceola averaged 3.8 years (n = 114, SE = 0.23); females and males averaged 4.2 (n = 47, SE = 0.38) and 3.5 (n = 67, SE = 0.29) years, respectively (Table 7). No difference in mean age was detected by sex among Osceola bears (t = 1.40, df = 112, P = 0.1651). Between study areas, however, Okefenokee females ($\bar{x}$ = 5.2 years) were older than those from Osceola ($\bar{x}$ = 4.1 years; Z = -2.150; P = 0.0316). Mean age of male bears did not differ by study area (Z = -0.551, P = 0.5816). Fifty percent (n = 171) of all captures were adults (Fig. 14).

Physical Characteristics.—Mean body masses of male and female bears were 86.3 kg (n = 179, SE = 2.81) and 53.2 kg (n = 116, SE = 1.35), respectively (Table 8). Adult females on Okefenokee and Osceola study areas averaged 55.5 kg (n = 50, SE = 1.78) and 63.9 kg (n = 24, SE = 2.68), respectively (Table 9). Mean weights of adult males averaged 107.3 kg (n = 50, SE = 4.03) and 133.5 kg (n = 26, SE = 5.31) on Okefenokee and Osceola study areas, respectively (Table 9).

Analysis of covariance (ANCOVA) indicated that the most significant source of overall variation in mean body weight was the result of a sex-age class interaction ($F_{2, 252}$ = 26.91, P < 0.0001). Male bears were heavier than females, and this variation was significantly greater for older age classes (adult > subadult > yearling). Interestingly, mean annual weights of Okefenokee males were significantly different between years ($F_{3, 97}$ = 2.85, P = 0.0415), but those of females were not ($F_{3, 60}$ = 0.18, P = 0.9067). Annual variation in body weights was not detected among males ($F_{2, 54}$ = 0.99, P = 0.3800) or females ($F_{2, 34}$ = 2.14, P = 0.1335) on the Osceola study area.

The ANCOVA test also indicated that bears, in general, were heavier on Osceola ($\bar{x}$ = 78.6 kg, n = 112, SE = 3.79) than Okefenokee ($\bar{x}$ = 70.0 kg, n = 183, SE = 2.25; F = 5.20, P = 0.0235). Ignoring the effect of age, the Student's t-test revealed that males from Osceola ($\bar{x}$ = 94.5 kg) were significantly heavier than Okefenokee males ($\bar{x}$ = 81.3 kg; t = 2.15, df = 112, P = 0.0334), but no difference in overall mean weights was detected between study areas for female bears (t = 0.98, df = 114, P = 0.3298). Comparisons between age classes, however, indicated adult females from Osceola ($\bar{x}$ = 63.9 kg) were significantly heavier than those on Okefenokee ($\bar{x}$ = 55.5 kg; t = 2.67, df = 72, P = 0.0093). Likewise, adult males were heavier on Osceola ($\bar{x}$ = 133.5 kg) than Okefenokee ($\bar{x}$ = 107.3 kg; t = 3.86, df = 74, P = 0.0002). Overall, adult bears on Osceola were 19% heavier than those on Okefenokee (t = 2.96, df = 148, P = 0.0036). We classified 35% of captured bears in excellent condition, 40% were good, 18% were fair, and 7% were classified as being in poor condition. Although no differences were detected between study areas ($\chi^2_{0.05}$ = 3.02, 3 df, P = 0.3892), males generally were in better condition than females ($\chi^2_{0.05}$ = 21.13, 3 df, $P < 0.0001$) based on our subjective rankings. Chest markings were present on 66 of 206 (32%) individual bears captured. Twenty-three of 76 males (30.3%) and 18 of 52 female (34.6%) bears on the Okefenokee area had chest markings. On Osceola, 13 of 48 males (37.5%) and 12 of 30 females (40%) exhibited marks. The incidence of chest markings did not differ by study area ($\chi^2_{0.05}$ = 0.00, 1 df, $P = 0.9976$) or sex ($\chi^2_{0.05}$ = 1.29, 1 df, $P = 0.2555$).

Radio Telemetry

We obtained 13,573 radiolocations from 87 (16M:71F) individual bears from July 1995 to December 1999. On the Okefenokee study area, 8,351 radiolocations were collected from 62 (16M:46F) bears; aerial telemetry accounted for 84% (n = 7,014). Twenty five female bears on Osceola were radiocollared; 71% (n = 3,718) of those locations were recorded from the air. Overall, 12,621 radiolocations remained for home range and habitat analyses after eliminating multiple den locations and bears with $\leq$30 observations.

Telemetry Error

We obtained 90 test locations throughout the Okefenokee and Osceola study areas from February 1996 to December 1999. Telemetry error was estimated from locations of 52 test collars, 26 dropped collars, and 12 visited den sites. Our mean errors for aerial and ground telemetry were 130.1 m (n = 48, SE = 12.3) and 117.3 m (n = 42, SE = 10.6), respectively. Because mean error did not differ between those methods (t = 0.78, df =88, $P = 0.4378$), we decided to pool our test collar locations. Consequently, our overall mean error was 124.1 m (n = 90, SE = 8.2). Ninety five percent of all estimated locations were within 255 m of the true coordinates.

Survival

We equipped 87 (16M:71F) captured bears with radio collars during this study, 62 (16M:46F) on Okefenokee and 25 (25F) on Osceola. Overall, we monitored 99 bear units (12 individuals were monitored for 2 time periods) for survival analysis. Bears were monitored for 54,863 radio days from 20 July 1995 to 29 December 1999.

We documented 82 bear mortalities on the Okefenokee (n = 75) and Osceola (n = 7) areas during this study (Table 10). Seventeen mortalities of radiocollared bears were documented on Okefenokee, with hunting mortality accounted for 70.6% of those deaths

(Table 11). Eleven (24%) radiocollared females from the Okefenokee study area died from 1995–1999. Seven females were legally harvested outside ONWR, 3 died of natural causes, and 1 from a vehicle collision. From 1996–1999, we documented only 2 (8%) mortalities of radiocollared females from Osceola; both were the result of illegal harvest. Bear 227 was killed by a bowhunter on the first day of archery season for deer in 1997, and bear 205, along with her 2 female cubs, was found shot over a deer bait site in December 1999. Sixteen males were radiocollared on the Okefenokee area; 8 dropped their collars, 6 died, and only 2 were alive at the end of the study. Hunting mortality accounted for 5 deaths and 1 bear was euthanized because of chronic beeyard depredation.

Annual survival for radiocollared females on Okefenokee ranged from 0.79 to 0.95 and, when combined for all years, equaled 0.87 (95% CI = 0.80–0.93; Table 12, Fig. 16). Annual survival rates for females ranged from 0.92 to 1.00 on the Osceola study area, with an overall rate of 0.97 (95% CI = 0.92–1.00) when years were pooled. Overall survival rates were lower for Okefenokee compared to Osceola females ($\chi^2_{0.05}$ = 3.98, 1 df, P = 0.0460).

Overall annual survival for male bears on the Okefenokee study area was 0.70 (95% CI = 0.53–0.88). Although probability levels neared statistical significance, we detected no difference in overall survival rates between Okefenokee males and females ($\chi^2_{0.05}$ =7.32, 1 df, P = 0.0673). Unfortunately, our statistical power to detect such differences was low because of the relatively small number of male bears that were radiocollared each year ($\leq$12). As illustrated by Pollock et al. (1989), the precision of survival estimates obtained using the Kaplan-Meier staggered entry procedure is poor when <20 animals are tagged at a particular time.

Treating the 7 harvested female bears on the Okefenokee area as censored, the annual survival rate for females increased from 0.87 to 0.95 (95% CI = 0.91–1.00). The annual harvest rate for females was 8%. Likewise, overall survival for Okefenokee males rose from 0.70 to 0.92 (95% CI = 0.79–1.00). Eighty-three percent (n = 6) of the mortality among radiocollared males was from harvest, or a 22% annual harvest rate.

Overall, 67 bears (51M:16F) were taken by hunters on the Okefenokee study area from 1995–1999 (Table 13). Mean body masses of male and female bears harvested on the Okefenokee study area were 108.8 kg (n = 50, SE = 5.04) and 69.6 kg (n = 15, SE = 4.56), respectively (Table 14). Although males were heavier than females ($F_{9,55}$ = 15.83, P = 0.0002), mean weights of harvested bears were not statistically different between years for either sex (P > 0.4705). The sex ratio of harvested bears was 51M:16F, which differed from a 1:1 sex ratio ($\chi^2_{0.05}$ = 18.28, 1 df, P < 0.0001) (Table 15). Annually, sex ratios of harvested bears favored males every year except 1996 ($\chi^2_{0.05}$ = 0.40, 1 df, P = 0.5271) and 1999 ($\chi^2_{0.05}$ = 2.88, 1 df, P = 0.0896). Average ages of male and female bears harvested on the Okefenokee study area were 4.6 (n = 50, SE = 0.35) and 5.0 (n = 12, SE = 0.82), respectively. No difference in mean age was detected by sex (t = 0.51, df = 60, P = 0.6094).

We tallied 136 radiodays when bears were available to harvest out of 653 radiodays during the 1995–1999 bear seasons (Table 16). Radiocollared bears were available to still hunting and hunting with hounds on 40 and 97 occasions, respectively. Of those 136 occasions that bears were available to harvest, 11 were killed. On average, 4.53 radiotagged bears were available to hunters per day, of which 0.37 were harvested, or a daily harvest rate of 8.1% (95% CI = 3.5–12.7%). Thus, bears that were available to harvest had a 48.5% chance of being taken by hunters during a season. Including the bears that were unavailable to harvest, the daily harvest rate was 1.7% (95% CI = 0.7–2.7%) or 10.2% annually. Hunting with the aid of dogs accounted for 10 (4M:6F) mortalities, and the remaining bear was a male taken by a still hunter. Hunting mortalities of radiocollared bears comprised 16% (n = 11) of the harvest on the Okefenokee area. Overall, tagged bears accounted for 55% (n = 37) of all harvested bears during this study.

Hunting with dogs was the most productive harvest method on the Okefenokee area. Mortalities from hunting with hounds and still hunting accounted for 57 (44M:12F) and 10 (8M:2F) bears taken from 1995 to 1999. Shotgun, rifle, bow, and pistol were used to harvest bears on 31, 29, 2, and 1 occasions, respectively. Residents of Georgia, Florida, and Alabama accounted for 45, 18, and 2 bears that were reported on the study area. The average number of houndsmen per successful party was 14.6 (n = 54, SE = 0.98) (Table 17). The number of dogs used per successful hunt ranged from 2 to 30, with an average of 6.7 (n = 54, SE = 0.45). Most successful hunts were over fairly quickly; bear chases averaged 3.1 km (n = 54, SE = 0.40) and lasted 1.18 hours (n = 54, SE = 0.11).

Population Size and Density

Eighty-eight and 94 barbed wire hair traps were maintained from 12 June to 17 September 1999 on the Okefenokee and Osceola study areas, respectively. We buffered each of the 1999 hair trap sites in the Okefenokee area with the average home range radius of 3,198 m. Similarly, each hair trap site in the Osceola area was buffered with the average radius of 4,330 m. This resulted in an estimated study area size of 511 km^2 at Okefenokee and 366 km^2 at Osceola (Fig. 17).This resulted in an average density of 1 hair trap per 5.8 km^2 on the Okefenokee study area, or approximately 7 and 24 hair traps per female and male home range, respectively. On the Osceola study area, hair trap density was 1 per 4.1 km^2, or approximately 13 traps per female home range and approximately 34 hair traps per male home range, based on our home range estimates for Okefenokee males. Our hair trap densities exceeded those suggested by Otis et al. (1978).

Eight hundred and eighty hair-trap sessions (88 traps x 10 trapping occasions) were recorded on the Okefenokee study area in 1999. Overall, 435 bear visits were documented, of which 374 (86%) produced ≥1 hair sample (Table 18). Of the 374 hair captures on the Okefenokee study area, 109 (29%) samples contained ≥5 roots, making them candidates for microsatellite analysis. Hair-trapping success was 42.5% on the Okefenokee study area in 1999, averaging 2.4 trap sessions per hair-capture event.

On the Osceola study area, 1,034 hair-trap sessions resulted in 742 bear visits in 1999, of which 637 (86%) produced ≥1 hair sample (Table 18). Two hundred seventy-two (43%) of the 637 hair samples collected contained ≥5 roots. Hair-trapping success on the Osceola study site was 61.6%, averaging 1.6 trap sessions per capture event.

Complete multi-locus microsatellite genotypes were obtained from hair and tissue samples for 111 of 121 (92%) and 72 of 79 (91%) live-captured bears on the Okefenokee and Osceola study areas, respectively. On the Okefenokee study area, 79 hair samples were selected for microsatellite analysis from the 1999 hair-trapping season. Complete multi-locus genotypes were obtained for 78 (99%) of those samples, of which 39 individual bears were identified. At each locus, 5–8 alleles were observed (Table 19) and average heterozygosity for the 8 loci was 66.3% ($n = 39$). Microsatellite analysis resulted in 8, 3, 3, and 5 bears being identified at hair traps in 1999 that were initially captured in 1995, 1996, 1997, and 1998, respectively.

On the Osceola study area, 88 hair samples were selected for microsatellite analysis; complete genotypes were obtained for 84 (96%) samples. Thirty-seven individual bears were identified on the Osceola study area. At each locus, 4–8 alleles were observed (Table 20) and average heterozygosity was 67.9% ($n = 37$). Twelve, 5, and 6 bears initially captured in 1996, 1997, and 1998 were identified at hair traps in 1999, respectively.

Based on the frequency distribution of alleles at the 8 microsatellite loci, the $PI_{overall}$ for 39 individual bears sampled with hair traps on the Okefenokee study area was 6.57×10^{-8} (Table 21). That corresponded to 1 chance in 15,223,017 that 2 individuals drawn at random from the Okefenokee population would share an identical genotype across all loci. The overall PI*sibs* was estimated at 1.00×10^{-3} ($n = 39$; Table 21), or 1 chance in 1,000 of encountering matching genotypes from another bear. Estimates of PI*sibs* for individual loci ranged from 0.388 to 0.533. The sibling match test for each 8-locus genotype was $P_{sib} < 0.003$. Consequently, all genotypes identified from 1999 hair traps were included in the capture history data based on our criteria for inclusion ($P_{sib} \leq 0.05$).

The $PI_{overall}$ for 37 individuals identified with hair traps on the Osceola study area was 2.92×10^{-7} (Table 22), or 1 chance in 3,421,763 of randomly sampling 2 bears possessing identical genotypes. PI*sibs* across the same 8 loci was estimated at 2.00×10^{-3} ($n = 37$; Table 22), approximating a 1 in 500 chance of encountering matching genotypes in the Osceola bear population. PI*sibs* estimates for individual loci ranged from 0.349 to 0.664. The sibling match test for each 8-locus genotype was $P_{sib} < 0.005$, again allowing us to include all observed genotypes in the capture history data.

For the 39 individual bears identified at hair traps on the Okefenokee study area in 1999, the Hardy-Weinberg equilibrium test detected evidence of non-random mating for 2 loci (G10M, $P = 0.016$; G10P, $P = 0.0003$) at the 5% significance level. Only locus G10P provided evidence of non-random mating, after applying the Bonferroni experiment-wise error rate (Rice 1989, Sokal and Rohlf 1995). On the Osceola study area, no evidence of non-random mating was detected among the 8 microsatellite loci examined for the 37 individual bears that were identified in 1999.

Linkage disequilibrium tests were used to identify possible non-random associations between alleles of different microsatellite loci. On the Okefenokee study area, 4 loci pairs (G10C vs. G10B, P = 0.00014; G1A vs. G10B, P = 0.00103; G1A vs. G1D, P < 0.0001; G10X vs. G1D, P < 0.0001) had probability values smaller than the comparison-wise significance level of 0.0018. Pairwise tests comparing the 37 individual bears identified at hair traps on the Osceola study area in 1999 detected no associations between any locus pairs.

The equal catchability test described by Caughley (1977) indicated that observed capture frequencies from the Okefenokee study area differed from the expected zero-truncated Poisson distribution when all of the hair-captures from 1999 were considered ($\chi^2_{0.05}$ = 13.790, 1 df, P = 0.0002; Table 23). Although the behavioral response test within Program CAPTURE produced nonsignificant results for the 10-session pooling arrangement, the probability value associated with this test was low ($\chi^2_{0.05}$ = 3.533, 1 df, P = 0.060). Additional tests, however, detected individual heterogeneity among capture probabilities for all pooling configurations (n = 5) of the 1999 hair data. Time variation was not detected as a significant influence on capture probabilities in any of the pooling arrangements. Based on the above, we gave further consideration only to models that allowed for variation in capture probabilities as a result of behavioral response or individual heterogeneity.

To aid in selecting the most appropriate pooling configuration for our analysis, we used the population closure test in Program CAPTURE. The tests for closure detected lack of closure at Okefenokee when 10 (Z = -3.451, P = 0.00028) and 5 (Z = -2.485, P = 0.00649) session pooling configurations were considered. Additionally, lack of closure was detected for 1 (3–3–4) of the 3-session pooling configurations (Z = -1.732, P = 0.0416). The population closure test failed to detect a lack of closure, however, for the 4–3–3 (Z = -1.414, P = 0.0787) or 3–4–3 (Z = -1.581, P = 0.0569) 3-session pooling configurations. Although 41% (n = 32) of the 79 samples were excluded from our analysis using the 4–3–3 arrangement, capture probabilities were higher and standard errors lower than for any other pooling configuration. Therefore, we selected the 3-session pooling configuration that divided capture histories into sampling periods of 36, 27, and 27 days each (Fig. 6).

Multiple mark-recapture models produced 1999 population estimates that ranged from 71–292 bears on the Okefenokee study area (Table 24). The jackknife heterogeneity model M_h produced a population estimate of 71 bears during the 1999 hair-trapping season, corresponding to a density of 0.14 bears/km^2. Model Chao M_h produced a population estimate of 175 bears, or 0.34 bears/km^2. The goodness-of-fit test for the individual heterogeneity models did not indicate a poor fit ($\chi^2_{0.05}$ = 0.054, 2 df, *P* = 0.973), but a poor fit was indicated for the behavioral response model M_b ($\chi^2_{0.05}$ = 7.356, 2 df, *P* = 0.0253).

On the Osceola study area, the equal catchability test (Caughley 1977) indicated that the observed capture frequencies from 1999 did not differ from the expected zero-truncated Poisson distribution when all hair-captures were considered ($\chi^2_{0.05}$ = 1.457, 2 df, *P* = 0.483; Table 25). Furthermore, goodness-of-fit tests indicated that capture probabilities were not significantly influenced by trap heterogeneity, behavioral response, or time variation for any pooling configurations (*n* = 4). The population closure test in Program CAPTURE failed to detect a lack of closure for all pooling configurations (*P* = 0.06–0.60). The largest probability value was associated with the pooling configuration that collapsed capture histories into 5 sampling sessions (*Z* = 0.262, *P* = 0.60). Furthermore, only 19 (23%) of the 84 hair samples were excluded from analysis due to multiple observations within a session. Therefore, we selected the 5-session pooling configuration that divided capture histories into 4 sampling periods of 18 days each with the fifth session lasting 27 days (Fig. 7).

Population estimates ranged from 44–50 bears on the Osceola study area using the multiple mark-recapture models in Program CAPTURE (Table 26). The null model M_o produced a population estimate of 44 bears during the 1999 hair-trapping period, for a density estimate of 0.14 bears/km^2. The largest estimate was provided by model M_h, the heterogeneity model, which estimated population size on the Osceola study area at 50 bears, or 0.16 bears/km^2. The goodness-of-fit tests did not indicate a poor fit for the individual heterogeneity, behavior response, or time variation models.

Estimates produced from Jolly-Seber models using stratified data indicated that capture probabilities were higher when capture data were pooled by sex and age. In addition, differences in population size estimates were negligible between pooled and stratified models. If heterogeneity in capture probabilities was present, it appears that increasing sample sizes made the Jolly-Seber models more robust to that violation. Therefore, we chose to pool sex and age classes for the 1995–1998 livetrapping data.

The equal catchability test described by Caughley (1977) indicated that the observed capture frequencies differed from a zero-truncated Poisson distribution ($\chi^2_{0.05}$ = 17.337, 2 df, P = 0.000129) on the Okefenokee study area, but not ($\chi^2_{0.05}$ = 7.092, 3 df, P = 0.06902) on the Osceola study area (Tables 27 and 28). Goodness-of-fit tests indicated that model A', the deaths only model, did not provide a good fit for the Okefenokee data (P = 0.0004). In addition, capture probabilities for model A' (p = 0.28) were low in comparison with models A, B, and D (p = 0.48–0.52). Therefore, only models A, B, and D were given further consideration. Model A produced a mean population estimate of 68 bears, corresponding to a density of 0.13 bears/km^2 on the Okefenokee study area (Table 29). Models B and D produced mean estimates of 73 and 77 bears, or 0.14 and 0.15 bears/km^2, respectively (Table 29).

On the Osceola study area, Jolly-Seber models produced mean population estimates that ranged from 90–114 bears (Table 29). Individual tests between models indicated that allowing survival and capture probabilities to vary did not provide a better fit to our data. Consequently, only models B and D were given further consideration. Model B, which is based on the assumptions of constant survival and time-specific capture probabilities, produced a mean population estimate of 95 bears on the Osceola study area, resulting in a density estimate of 0.26 bears/km^2 (Table 29). Model D, the constant survival and capture probability model, provided a mean population estimate of 93 bears, or 0.25 bears/km^2 (Table 29). Mean capture probabilities for models D and B were 0.40 and 0.41, respectively.

Reproduction and Denning

We monitored 66 radiocollared bears (8M:58F) from 1995–1998 for 132 possible denning occasions. Bears on the Okefenokee study area denned on 94% (*n* = 82) of the possible occasions; 5 Okefenokee bears (1M:4F) remained active for 1 denning season. Female bears on the Osceola area denned on 100% (*n* = 39) of the denning occasions; the denning status of 6 females was unknown.

Mean dates of den entry and emergence for radiocollared males (*n* = 9) on Okefenokee were 31 December (SE = 5.9 days) and 12 March (SE = 6.0 days), respectively (Table 30). Denning periods for males averaged 71.6 days (SE = 8.8). Den entry and exit dates for female bears (*n* = 109) averaged 19 December (SE = 1.8 days) and 26 March (SE = 2.1 days), respectively. Duration of denning for females ($\bar{x}$ = 96.7 days, *n* = 109, SE = 2.7) was longer than for male bears (Z = -2.38, *P* = 0.0174). Among all radiocollared female bears, den entry (*P* < 0.0001) and length of denning period (*P* < 0.0001) differed by reproductive status, but no differences were detected in den emergence dates (*P* = 0.6892).

On the Okefenokee study area, pregnant females denned earlier (*P* < 0.0001) and longer ($\bar{x}$ = 105.6 days, *n* = 35, SE = 4.3) than non-pregnant females ($\bar{x}$ = 83.1 days, *n* = 29, SE = 4.9; *P* = 0.0008). Likewise, pregnant females on Osceola entered dens earlier (*P* < 0.0001) and denned for longer periods ($\bar{x}$ = 110.0 days, *n* = 22, SE = 5.4) than non-pregnant females ($\bar{x}$ = 73.3 days, *n* = 13, SE = 4.1; *P* = 0.0002). Mean dates of den emergence, however, did not differ between pregnant and non-pregnant females on Okefenokee ($P \leq 0.4447$) or Osceola ($P \leq 0.1105$). Mean dates of den entry (*P* = 0.9093), den emergence (*P* = 0.2180), and the duration of denning periods (*P* = 0.4712) did not differ between solitary females and those with yearlings.

Annual variation in denning chronology also was apparent for females on both study areas. (Table 31). Okefenokee females denned earlier (*P* < 0.0001) and remained in dens for a longer duration (*P* = 0.0012) in 1996 than 1995. Only emergence dates differed between 1997 and 1998 denning seasons (*P* = 0.0016). Among radiocollared females on the Osceola study area, den emergence in 1998 (7 March) was earlier than all other years ($P \leq 0.0091$).

We documented den types used by Okefenokee and Osceola bears on 88 (2M:86F) occasions from 1995–1998. The 2 male bears from Okefenokee denned in ground nests each year. Tree cavities (n = 18) and ground nests (n = 16) accounted for 65% of all dens used by Okefenokee females. We documented Okefenokee bears using stumps and cavities at the base of trees and on 4 and 10 occasions, respectively. In contrast, ground nests accounted for 100% (n = 37) of all documented den types used by female bears on the Osceola study area.

Bears used a variety of habitats for denning locations during this study. Bears on Okefenokee used shrub, blackgum, mixed shrub, and cypress on 24, 23, 21, and 13 instances, respectively (Table 32). Interestingly, 90% (n = 74) of all radiocollared bears on the Okefenokee study area denned within the boundaries of ONWR during 1995–1998 (Fig. 17). Ninety seven percent (n = 38) of all Osceola females denned in shrub communities (Fig. 19). Only 1 radiocollared female from each area (n = 2) denned in pine habitat during this study.

During the 1995–1998 reproductive seasons, we investigated 50 (3M:47F) den sites of 28 (3M:25F) Okefenokee bears. On the Osceola study area we successfully located 20 female den sites belonging to 14 individuals. In addition, we successfully determined the sizes of 34 and 22 litters on the Okefenokee and Osceola study areas, respectively (Table 33). Sex ratios of litters were not determined because cubs were not handled.

Overall, mean litter sizes were the same for Okefenokee ($\bar{x}$ = 2.1, n = 34, SE = 0.64) and Osceola ($\bar{x}$ = 2.1, n = 22, SE = 0.68) females. Annual cub production, however, differed between the 2 areas. On the Osceola study area, 46 cubs were born from 8, 5, and 9 litters in 1997, 1998, and 1999, respectively. In contrast, 99% (n = 69) of all documented cub births on the Okefenokee area occurred in 1997 and 1999. Interestingly, only 1 of 15 solitary females on the Okefenokee study area produced cubs in 1996. Although only 2 unencumbered females were radiocollared during the 1998 denning season, both failed to produce cubs. Overall reproductive success also appeared to vary between age classes during this study. Among Okefenokee females, we documented no cub production among radiocollared bears $\leq$3 years old (n = 4). During the 1997 trapping season on Osceola, however, we captured a 4-year-old female with yearlings and a lactating female that was aged as a 2-year-old. In addition, we treed 2 subadult females with cubs during the 1998 denning season. Interestingly, both radiocollared females that were treed also had been aged at 2 years.

Population Modeling

Okefenokee study area.—Variances for most rate parameters were relatively small, with the exception of the proportion of females with litters (Table 34). Because of the variability in food production from year to year, the proportion of females that were capable of producing cubs that actually produced them ranged from 0 to 1.0 annually. Thus, the standard error for that rate parameter was large.

Beginning in 1999 on the Okefenokee study area, the average growth rate of the population (λ) over the following 10 years without a harvest was 1.064 (SD = 0.066). The variability among individual runs was high (Fig. 20), and the 95th percentile of population means after 10 years (134.5) ranged from 67 to 194 (Fig. 21). No extinctions occurred under this modeling scenario.

When the average annual harvest from 1995–1999 (9.4 animals or 13.2%) was imposed on the population for 10 years beginning in 1999, average annual growth rates declined to 0.916 (SD = 0.072) and the population declined to 30.6 (SD = 20.5). Extinction occurred in 0.6% of the simulations over the 10-year period and in 58.3% after 25 years. When the average annual harvest level was reduced to 5 bears (7.0%), population growth was more stable at 0.993 (SD = 0.076) with no extinctions in any of the 1000 simulations during the 10-year period and 2% after 25 years.

Osceola study area.—Again, parameters for litter production rates had high coefficients of variation, though not as high as on Okefenokee (Table 35). Beginning in 1999 and based on a population size estimate of 44 (SE = 4.16), the average annual growth rate of the population without a harvest over the following 10 years was 1.184 (SD = 0.071), higher than at Okefenokee ($t = 3.93$, 18 df, $P = 0.0010$). Annual variability was high, as the 95th percentile of population means after 10 years (238.0) ranged from 106 to 411 (Fig. 22). Average growth rates for both study areas indicated some reproductive synchrony, but to a lesser extent than on the Okefenokee study area as evidenced by changes in growth rates by year (Fig. 23). Average ages for both sexes declined over time (Fig. 24). No extinctions occurred with this modeling scenario after 25 years.

Food Habits

Between June 1995 and December 1999, we identified 32 separate food items in 2,160 bear scats (1,457 Okefenokee, 703 Osceola). Ninety seven percent of the diet of bears was of plant origin. Spring diets of bears were dominated by shrub/vine fruits, which accounted for 56% and 66% of the volume on Okefenokee and Osceola areas, respectively (Tables 36 and 37, Fig. 25). Blueberries (*Vaccinium* spp.) were the most prevalent item found in spring scats (by frequency of occurrence and volume) on both study areas. Although huckleberries (*Gaylussacia* spp.) accounted for 23% of spring scats by volume on Okefenokee, this item was not detected in the diet of Osceola bears. Conversely, blackberries (*Rubus* spp.) were not observed in Okefenokee scats, but volumetrically contributed to 12% of spring scats on the Osceola area. Corn also was an important food in spring diets, accounting for 14% and 22% of the volume on Okefenokee and Osceola areas, respectively.

Animal matter, primarily beetles (Coleoptera) and ants (Formicidae), occurred in 32% of spring scats on Okefenokee, but represented only 8% of spring diet by volume. Likewise, animal matter was found in 15% of spring scats on Osceola, but contributed only 3% by volume. White-tailed deer was the only vertebrate found in spring scats on Osceola. On Okefenokee, however, we identified armadillo (*Dasypus novemcinctus*), feral hog, reptile eggs, and white-tailed deer in spring scats.

Shrub/vine fruits contributed to 51% of summer scats by volume on both study areas. Food items eaten by bears during summer differed from those eaten in the spring. Sweet gallberry occurred most frequently and accounted for 32% and 23% of summer scats by volume on Okefenokee and Osceola, respectively. Blueberries, which dominated spring diets, occurred in <2% of scats in summer. By volume, saw palmetto (*Serenoa repens*) and grapes (*Vitis* spp.) accounted for the remaining majority of soft mast species in summer scats. Apart from shrub/vine fruits, corn was the second most important food item in the summer diets of Okefenokee and Osceola bears. Corn represented 24% and 39% of summer scats by volume on Okefenokee and Osceola, respectively. In September, bears on Okefenokee began feeding on blackgum (*Nyssa* *sylvatica*), which volumetrically accounted for 9% of the total summer diet. Blackgum appeared only in trace amounts on Osceola during summer months. Vegetation contributed to 6% and 9% of summer scats by volume on the Okefenokee and Osceola study areas, respectively.

Similar to spring diets, animal matter was found in a relatively high proportion of scats (20%) on Okefenokee, but represented only 4% of summer diet by volume. Feral hog, bear, and reptile eggs were identified in summer scats on Okefenokee. Eleven percent of summer scats examined on Osceola contained animal matter; this accounted for 2% by volume. Reptile eggs and white-tailed deer were the only vertebrate species identified in summer scats on Osceola.

Although spring and summer diets were proportionally similar on Okefenokee and Osceola, fall diets varied considerably between the two areas. On Osceola, corn accounted for 40% of fall scats by volume, but represented only 2% of the volume on Okefenokee (Fig. 26). In contrast, tree fruit dominated the fall diet on Okefenokee, with blackgum and acorns (*Quercus* spp.) accounting for 37% and 21% of scats by volume. Although blackgum represented 22% by volume on Osceola, acorns were not found in any fall scats. The remainder of the fall diet primarily consisted of palmetto fruit, which accounted for 30% and 33% of the volume on Okefenokee and Osceola, respectively.

In addition to analysis of scats, the stomach contents of 19 harvested bears also were examined during fall on the Okefenokee study area. Stomachs were volumetrically dominated by blackgum (33%), corn (22%), animal matter (20%), and palmetto fruit (16%). Blackgum was the most prevalent food item in stomachs and scats during fall. Corn occurred in relatively high percent volume in stomachs, however, when compared to fall scats (2%). Animal matter also was found in greater proportions by volume in stomachs of harvested bears than in fall scats (<1%). Interestingly, the stomach of 1 female bear contained the remains of an entire armadillo.

The winter diets of Okefenokee and Osceola bears exhibited marked differences in the occurrence and variety of food items consumed. On Osceola, 3 food items contributed to 92% of winter scats by volume; palmetto fruit, corn, and bitter gallberry accounted for 68%, 25%, and 13%, respectively. Winter scats on Okefenokee, however, were dominated by greenbriar (*Smilax* spp.) and debris; these accounted for 33% and

25% of winter diet by volume. Curiously, greenbriar and debris were rare or absent in winter scats on Osceola. Other important plant items that contributed to the volume of winter scats on Okefenokee were moss (*Sphagnum* spp.), acorns, and bitter gallberry; these accounted for 15%, 8%, and 5%, respectively. Animal matter, which contributed to 9% of the winter diet by volume, was found in 35% of scats examined on Okefenokee. Although the occurrence of animal matter in the winter diet of Okefenokee bears was dominated by ants and beetles, white-tailed deer accounted for the greatest percent volume (5%).

The aggregate annual diet of bears on the Okefenokee study area was volumetrically dominated by tree fruit (51%) and shrub/vine fruit (39%; Tables 36 and 37, Fig. 27). Blackgum, saw palmetto, and acorns accounted for 32%, 26%, and 17% of the annual volume, respectively. On Osceola, however, shrub/vine fruit (45%) and corn (37%) contributed the most to annual diet by volume. Although blackgum was the most important food item in the annual diet of Okefenokee bears, it accounted for only 11% on Osceola. Animal matter frequently occurred in Okefenokee (13%) and Osceola (9%) scats, but represented no more than 1% of the annual diet on both areas. Vegetation and debris cumulatively accounted for 4% of annual diet by volume on Okefenokee and Osceola.

Although pooling the data across years revealed important differences in food habits between study areas, it masked annual fluctuations that occurred on both study areas. Acorns, which accounted for 62% of the fall diet in 1995 on Okefenokee, comprised <20% of the 1996 fall diet, and was nonexistent or occurred only in trace amounts from 1997–1999. In contrast to Okefenokee where a heavy mast crop occurred in 1995, acorns were never detected in Osceola scats during that year. Only in 1997 were acorns identified the annual diet of Osceola bears, accounting for <2% volume.

Blackgum was a more consistent producer than oaks on Okefenokee. Although it also exhibited annual fluctuations in crop abundance, blackgum accounted for ≥16% of annual scat volume each year of this study. Following a blackgum shortage in 1995, we observed an unusually abundant crop in 1996; this was reflected in our scat analysis. The same pattern was repeated in 1997 and 1998 on Okefenokee, suggesting blackgum mast fluctuations were biennial. On the Osceola study area, however, blackgum accounted for

<4% of scat volume each year except 1998 (29%). Interestingly, during the exceptional blackgum crop of 1996 on Okefenokee, blackgum represented <2% of the annual volume on Osceola.

Annual variation in the abundance and consumption of shrub/vine fruits also was documented in each study area. Although tree fruits dominated the annual diets of Okefenokee bears in 1995 (76%), 1996 (64%), and 1998 (61%), shrub fruits were the primary food source in other years. In 1997, when blackgum production was moderate, a variety of shrub/vine fruits accounted for 35% of scat volume. In 1999 by contrast, 66% of the Okefenokee diet was composed of palmetto fruit.

Unlike Okefenokee, Osceola bears heavily exploited corn from deer feeders each year of the study. From 1996 to 1999 on Osceola, corn accounted for 15%, 53%, 48%, and 30% of scat volumes, respectively. While those proportions are relatively high, they are not surprising considering we documented 79 deer feeders on the Osceola area (Fig. 28). Although shrub/vine fruits accounted for $\geq$19% of scat volume each year on Osceola, they exhibited annual fluctuations in crop abundance. The supply of corn, however, was relatively stable on the Osceola area. Interestingly, shrub/vine fruits were especially abundant in 1996 and 1999, and accounted for 78% and 60% of the annual scat volumes. The lower use of corn during years of abundant shrub/vine fruits, particularly saw palmetto, suggests that bears prefer these natural foods when available.

Home Range Analysis

Annual home range size for males and females on the Okefenokee study area averaged 342.8 km^2 (n = 10, SE = 71.5) and 55.9 km^2 (n = 69, SE = 6.9), respectively (Table 38, Figs. 29 and 30). The mean annual home range size for Osceola females ($\bar{x}$ = 30.3 km^2, n = 53, SE = 4.0) was roughly half that of Okefenokee females (Z = -2.47, P = 0.0136; Table 38,Fig. 31). Although no differences were detected between age classes for either sex on Okefenokee (Table 39), adult females ($\bar{x}$ = 32.9 km^2, n = 45, SE = 4.6) had larger home ranges than subadults ($\bar{x}$ = 15.6 km^2, n = 8, SE = 2.5) on Osceola (Z = -2.67, P = 0.0076). Likewise, annual home ranges of subadult females on Okefenokee averaged 67.3 km^2 (n = 8, SE = 16.1), and were roughly 4 times the size of subadults on Osceola (Z = -2.89, P = 0.0019). Because only 6 bears were equipped with radio collars for all years of study, we could not use a repeated measures analysis to compare home range sizes among years. However, we were able to use the nonparametric Wilcoxon signed rank test to compare home range sizes of bears that were monitored for ≥ 2 consecutive years. For Osceola females, no differences were detected between any successive year periods from 1996–1999 (S = -4 to 11, P = 0.2500 to 0.5966). On Okefenokee, we detected no differences in home range sizes between any consecutive years except 1998–1999 (S = -29, P = 0.0210). Paired comparisons among male bears were not performed due to small sample sizes.

Seasonal home range estimates for female bears were calculated for spring, summer, and fall (Table 40). Because of small sample sizes, statistical analyses did not include home range estimates for Okefenokee males during spring. Home ranges for Okefenokee females exhibited considerable variation in size across seasons ($F_{2,165}$ = 6.73, P = 0.0015; Table 40). Overall, female home ranges in summer ($\bar{x}$ = 43.7 km^2, n = 77, SE = 6.6) were larger than spring ($\bar{x}$ = 20.9 km^2, n = 15, SE = 7.5) and fall ($\bar{x}$ = 33.8 km^2, n = 76, SE = 6.5) on the Okefenokee area (t = -3.25 and -2.90, 90 and 151 df, $P \leq$ 0.0043). For Okefenokee males, mean home range size did not differ between summer ($\bar{x}$ = 207.1 km^2, n = 16, SE = 38.6) and fall ($\bar{x}$ = 273.8 km^2, n = 18, SE = 61.3; t = 0.55, 32 df, P = 0.5861). Seasonal home ranges for Osceola females averaged 17.4 km^2 (n = 19, SE = 3.5), 24.4 km^2 (n = 59, SE = 1.9), and 27.2 km^2 (n = 60, SE = 4.6) for spring, summer, and fall, respectively. Although seasonal home range sizes did not differ on Osceola, probability levels neared statistical significance ($F_{2,135,\ 0.05}$ = 2.95, P = 0.0559). Seasonal variation between study areas was detected only during summer, when the mean home range size for Okefenokee females was approximately twice that of Osceola females (t = -2.02, 127 df, P = 0.0453). Across years, fall was the only season when we observed dramatic fluctuations in female home range size. This was most apparent in 1998 and 1999, when mean home range size increased from 14.5 km^2 to 78.4 km^2 for Okefenokee females (Fig. 32).

Home range overlap was extensive for all radiocollared bears on the Okefenokee and Osceola study areas (Figs. 29 to 31). Of the 69 individual annual home range estimates calculated for female bears on the Okefenokee study area from 1996–1999, we documented only 1 occasion when a home range did not overlap with some portion of another female's home range. All male home ranges on the Okefenokee area overlapped one another. Likewise, 92% (n = 49) of all annual home ranges for Osceola females were shared with at least 1 other female.

Movement Patterns and Microhabitat Use

We documented 121 Rest events, 173 Forage events, 100 Search events, and 105 Travel events. After the patterns were identified, a 100 m buffer was created around each event to account for our estimated telemetry error (±117.3 m). We located and mapped 79 deer feeders interspersed throughout the Osceola study area (Fig. 33).

Only the Rest movement category showed significant differences between the cover types ($F_{3,15} = 8.94$, $P < 0.05$; Table 41). Pine Plantation and Forest Regeneration were used proportionately less ($P < 0.05$) for Rest events, whereas the Wetland Mixed Forest was used proportionately more. We did not detect disproportionate use of habitat by stand age for any movement category ($P > 0.05$; Table 42). However, only 7 bears were available for analysis because stand age data were limited.

Wetland Mixed Forest and Pine Plantation were the dominant habitat types, with 27.5% and 43.5% available to bears, respectively. Bears collectively spent over twice as much time (607 h) in Wetland Mixed Forest as they did in Pine Plantation (253 h; Table 43). Cumulative time spent within other cover types was minimal when compared to Wetland Mixed Forest and Pine Plantation.

Based on residence time, bears spent the majority of their time in non-plantation habitats (Table 44). When using plantations, most time was spent in 1-15 year old stands and use was similar within those categories.

Macrohabitat Use

Habitat rankings for each year from 1996–1999 were fairly consistent for each study area, and exhibited little variation in order of selection between years. In addition, habitat classes that switched rankings in consecutive years typically lacked a statistically significant difference in either direction. Consequently, we chose to pool annual home ranges and evaluate habitat use for each study area across all years. Because compositional analysis takes the animal as the sampling unit, pooling also provided an increase in sample size that likely resulted in more precise estimates of habitat selection.

The initial component of our compositional analysis (second-order selection) examined the locations of individual home ranges in relation to available habitats within the entire study area. On the Okefenokee study area, loblolly bay habitats ranked highest among the 7 habitat types (Table 45). Although a difference (P = 0.0068) in use was detected between loblolly bay and gum/bay/cypress, each showed significantly greater use than all remaining habitat classifications. Pine/oak associations accounted for only 6.4% of the Okefenokee study area yet showed a greater proportional use (P = 0.0005) than pine habitats, which comprised 27.5% of the available area. There was no detectable difference in use between disturbed areas or shrub wetlands, but each ranked higher than swamp forest habitats.

Our analysis of third-order selection evaluated how bears used available habitats within their home ranges, rather than the study area. For Okefenokee females, there were no changes in position for the 4 highest ranked habitat types between second and third-order selection (Table 45). For the within-home range analysis, however, we detected no difference in use between loblolly bay and blackgum/bay/cypress (P = 0.1303) or between pine/oak and pine (P = 0.7797). Swamp forest habitats ranked fifth overall and was used significantly more than the remaining habitat types (P = 0.0213).

Analysis of second-order selection for the Osceola study area indicated female home ranges were primarily located around blackgum/bay/cypress habitats relative to all other classifications (Table 46). Although the rankings for pine and swamp forests were interchangeable (P = 0.9778), they were used more than lower ranks. Likewise, loblolly bay forests and pine/oak communities did not differ in use (P = 0.9152), but were selected more than disturbed areas (P = 0.008) or shrub wetlands (P = 0.0005). For third-order selection, blackgum/bay/cypress habitats and swamp forests ranked highest among all habitat types (Table 46). Pine stands, which ranked second in relation to where home ranges were located within the Osceola area, ranked only fifth in habitat use at third-order selection. In contrast, shrub wetlands moved from the lowest ranked habitat variable in second-order selection, to the fourth most used type relative to available habitats within home ranges.

Apiary Depredation

We identified and described 51 beeyards on the Okefenokee study area (Fig. 34, Appendix 7). All beeyards were located in slash pine plantations with dominant vegetation being slash pine, palmetto, wax myrtle, bitter gallberry, and blueberry. All beeyards on the study area were enclosed with some form of electric fencing. Total fenced area averaged 337.7 m^2 (range 116–924 m^2) per beeyard. There were an average of 31.4 hives (range 18–76) and 23.2 supers (range 4–131) per yard.

Wire types used in construction of electric fences were mostly electrical wire and barbed wire, but electrical tape and woven wire also were used. Typically, 2–6 wire strands were used with at least 1 being electrified. Average fence height was 88.1 cm (range 58.4–127.0 cm). Power sources typically consisted of a single automobile battery connected to a voltage-regulating fence charger (6 or 12 volts). Solar panels were used on-site to recharge batteries except in areas where the likelihood of theft was high.

Of the 44 bears (8M:36F) whose home ranges met sample size requirements, only 28 (8M:20F) contained $\geq$1 beeyard. Of those bears, 4 (3M:1F) were trapped as nuisance bears at recently raided beeyards. The mean distance between beeyards and bear radiolocations was 3.64 km, ranging from 0.07 to 26.32 km. The mean distance between beeyards and random locations was 3.85 km (range = 0.04 – 26.67 km), which differed from the radiolocations (P = 0.008). Nuisance bears were located further from beeyards than non-nuisance bears ($\bar{x}$ = 5.63 km and 3.41 km, respectively; $P < 0.001$).

Average distances from beeyards to roads, bear bait sites, riparian zones, and the swamp edge were 710 m (range 7–8, 915 m), 1259 m (range 209–2,944 m), 2119 m (range 10–8,687 m), and 3,685 m (range 50–9,417 m), respectively. Distances to riparian zones were less for damaged ($\bar{x}$ = 1,750 m) compared to undamaged yards ($\bar{x}$ = 4,442 P = 0.0089) and damaged beeyards were closer to roads ($\bar{x}$ = 134 m) than undamaged beeyards ($\bar{x}$ = 802 m, P = 0.0089). Differences in distances between damaged and undamaged beeyards and bear bait sites and the swamp edge were not detected (P = 0.065 and 0.663, respectively).

From 1996–1998, 13 instances of bears raiding beeyards were documented; 7 occurred within the Okefenokee study area boundaries. All but 1 of the raided yards were enclosed with some form of electric fence. In all instances when the damage occurred, the fence was not active because of depleted batteries. We recorded from 1 to 8 destroyed hives per bear visit and in no instances were all the hives in a yard destroyed. Of the 13 depredation instances, 6 involved repeated visits by the bear. Those 6 beeyards yielded 6 bear captures (4M:2F; Table 47) with an average time until capture of 4 days.

Male and female nuisance bears averaged 2.0 and 2.5 years of age whereas non-nuisance bears with beeyards within their home ranges averaged 4.2 and 6.2 years of age for males and females, respectively.

Of the nuisance bears that we radiocollared at beeyards, a 2-year-old male and a 3-year-old female continued to raid beeyards. The male was eventually euthanized and the female was killed during the bear hunting season in 1998. The other 4 bears were not known to cause additional nuisance activity even though most remained in close proximity to beeyards.

Beekeepers returned 58 of 84 (70%) surveys. Each respondent maintained an average of 599 hives (range 0–3000) in 19 beeyards (range 0–120) in 1997. Of those, 13% were <1 mile (1.6 km) from the NWR boundary whereas 57% were >10 miles (16.1 km) from the boundary. Seventy-one percent of the respondents reported having problems with bears raiding their beeyards from 1993 to 1997. Most damages occurred in spring (36%), followed by summer (31%), fall (22%), and winter (10%). Thirty-five percent of the beekeepers that experienced damage considered the damage to be high, compared to 37% moderate, and 21% less than moderate. Average monetary losses ranged from $1,001 to $4,000. Most beekeepers (58%) felt that damage by bears had increased during the past 5 years and most (59%) felt this was because more bears were present in the area. Respondents reported that bears damaged an average of 6 of their beeyards per year (range 0–32).

Seventy-four percent of the respondents reported that they attempted to prevent bear damage to beeyards. Chemicals (22%) and trapping (27%) were the 2 most common methods used by the respondents but most deemed them to be ineffective. Electric fences were used by 14% of the respondents and all that had used them considered them to be at least somewhat effective. When asked to indicate their preferred method for addressing bear damage in the future, most beekeepers chose special permit harvesting of nuisance bears at beeyards (41%) followed by the use of electric fences (19%).

When asked how they felt about bears in the area, 43% thought bears were a nuisance whereas 47% enjoyed seeing bears but worried about beeyard damage. Sixty-seven percent of the respondents felt that bear damage was unacceptable whereas 31%

felt that bear damage was unwanted but was recognized as a part of beekeeping in their area.

DISCUSSION

Trapping and Handling

Numerous black bear studies have documented sex ratios of captured bears that were skewed towards males (Hellgren 1988, Klenzendorf 2002). Whereas adult captures did not differ from a 1:1 sex ratio in our study, the age distribution of subadult bears was heavily skewed towards males on each area (Okefenokee – 79M:21F; Osceola – 50M:24F). Studies among intensively hunted bear populations have reported adult (>3 years of age) captures of <55% and an average age <4 years (Young and Ruff 1982, Beecham 1983, LeCount 1982, Klenzendorf 2002). The proportion of adult bears captured on Okefenokee was 53% (n = 113), and the overall mean age of captured bears 4.3 years. Interestingly, the proportion of captured adults (44%, n = 114) and overall mean age (3.8 years) of bears on the Osceola study area were even lower than Okefenokee, despite protection from hunting.

Mean body weights of adult bears from Okefenokee and Osceola fell within the range of weights reported from other southeastern coastal plain studies (Table 48.) Male bears from Osceola, however, were among the heaviest reported and both sexes on Osceola were heavier than bears at Okefenokee. The most probable reason for differences in weights between Okefenokee and Osceola bears may be the abundance of human-supplied corn on the Osceola study area. Corn is a high energy food that has been shown to influence many aspects of bear population dynamics (Landers et al. 1979, Martorello 1998, Beausoliel 1999, Boersen 2001, McDonald and Fuller 2001). Comprising 37% of their annual diet, corn from deer feeders provides Osceola bears with a consistent and abundant food supply throughout the year. In contrast, corn was available to bears on Okefenokee in small quantities, contributing to only 5% of their annual diet.

Survival

Survival estimates for radiocollared bears in this study was 0.70 for Okefenokee males, and were 0.87 and 0.97 for Okefenokee and Osceola females, respectively.

Whereas survival of Okefenokee bears was similar to other southeastern coastal bear populations, our estimate for Osceola females was among of the highest reported (Table 49). Hunting mortality accounted for 70.6% (*n* = 17) of the mortalities of radiocollared bears on Okefenokee. In addition, hunting accounted for 92.0% (*n* = 75) of all documented mortalities (including bears that were not radiocollared) on the Okefenokee study area. In contrast, only 6 deaths were documented on the Osceola area during this study; 2 of those were radiocollared females that were poached.

The sex ratio of bears harvested on the Okefenokee study area (53M:16F) indicate that harvest mortality was biased towards males. We were informed by hunt club members on many occasions that harvesting female bears was avoided whenever possible. Although hunting with hounds typically was not selective towards 1 sex, hunters often did not release dogs on small bear tracks. Furthermore, we documented several occasions in which female bears were treed, but not killed because hunters could see a radio collar and assumed it was a female. Although the number of radiocollared males was relatively small during this study, 5 of 6 (83%) of those bears were harvested. Consequently, survival rates for Okefenokee males appear to be primarily influenced by hunting mortality.

Survival estimates for Okefenokee females (0.87) were significantly higher than males (0.70). Although selective harvest by hunters may have some effect on female survival, it appears that seasonal movements in relation to food availability is the primary reason for higher survival rates for Okefenokee females. Fall diets of Okefenokee bears were dominated by blackgum fruit (61%), which typically became available in late September to early October. Bears left upland areas and traveled into swamp habitats in search of blackgum during that time. For counties surrounding ONWR the bear season begins at that same time, typically starting on the last weekend in September. As a result, a large proportion of female bears were unavailable for harvest because they were within the confines of ONWR exploiting the blackgum crop, during years when it was available. Whereas males also exploited the blackgum crop each fall, larger home ranges often resulted in bears leaving ONWR, making them more susceptible to harvest (Bunnell and Tait 1980). Given the importance of blackgum in the fall diet of Okefenokee bears, we speculate that survival was increased because the bear hunting season coincided with the onset of blackgum availability. When bears were available to harvest, hunter success rates were high (48.5%). Nevertheless, we knew of several occasions when radiocollared bears were within meters of hunting parties, but the scent was not detected by the hounds. If a trail was struck, however, the probability of success was high according to the hunters we interviewed.

Our annual survival estimate for Osceola females (0.97) was among the highest reported from any southeastern bear population, no doubt influenced by the closing of the bear-hunting season in and around Osceola NF in 1992. When survival estimates for Okefenokee females were recalculated without hunting mortality, overall survival rates increased from 0.87 to 0.95, similar to that of the Osceola females.

Population Size and Density

Program CAPTURE’s chi-square goodness-of-fit tests identified significant patterns of variation in capture probabilities for many of the data pooling configurations on the Okefenokee study area. The most obvious pattern was a consistent detection of individual heterogeneity in capture probabilities**;** temporal or behavioral responses were not detected. Therefore, we gave further consideration only to those models that allowed for individual capture heterogeneity. The population estimate of 175 bears produced by model Chao M_h was the second highest of all multiple mark-recapture models considered. However, simulation results indicate that model Chao M_h tends to overestimate in the presence of weak heterogeneity (Mowat and Strobeck 2000), which was the case at Okefenokee. Consequently, we conclude that the within-year estimate of 71 bears (95% CI = 59–91) produced by the jackknife heterogeneity model M_h was the most appropriate for the Okefenokee hair-trapping data.

The Jolly-Seber model A produced a mean population estimate of 68 bears (95% CI = 50–85) on the Okefenokee study area based on 4 years of live-capture data and 1 year of hair-trapping data. With the exception of the deaths only model A’, all models exhibited similar annual trends and produced mean estimates that differed by only 9. Estimates from model A’ were seriously elevated and lacked precision relative to other models. The deaths only model also was probably biased due to bears moving out of ONWR and onto the study area. Models B and D are based on assumptions of constant survival rates, and high capture probabilities probably made these models robust to model violations. However, 46 of the 52 bear mortalities documented during the 4 years of live trapping on the Okefenokee study area were due to hunting. Consequently, we did not give further consideration to models B and D and, instead, chose the mean estimate of 68 produced by the general Jolly-Seber model A, which accounts for variation in survival probabilities.

Unlike the Okefenokee study area, capture probabilities for the Osceola hair-trapping data did not appear to be influenced by individual heterogeneity. Because time and behavioral variation also were not detected, it was not surprising that Program CAPTURE selected the null model M_o. Based on the absence of heterogeneity in capture probabilities, we selected the estimate of 44 bears provided by the null model M_o as most appropriate during 1999.

The Jolly-Seber models B and D produced mean population estimates of 95 (95% CI = 38–153) and 93 (95% CI = 43–143) bears on the Osceola study area, respectively. Estimates provided by Jolly-Seber models were much higher than the within-year estimate of 44 provided by the closed model M_o; however, the Jolly-Seber models performed poorly. For example, survival estimates from model A exceeded 1.20, a biological impossibility. The poor performance of the Jolly-Seber models seemed to be because of a lack of recaptures from the 1997 trapping season. Of the 26 bears that were initially marked in 1997, only 5 were recaptured in 1998; 15 bears from 1996 were caught in 1998. Likewise, only 5 bears that were initially marked in 1997 were identified at hair traps in 1999, whereas 12 bears from 1996 were observed in 1999. It appears that the observed positive bias is most likely due to an inability to recapture some marked individuals, which will result in an overestimation of population size (Pollock et al. 1990). Therefore, the Jolly-Seber models were not given further consideration for Osceola.

Given all data pooling configurations and model types used in this analysis, we conclude that the most reliable estimates of population size were obtained from closed models using the 1999 hair-trapping data. For the Okefenokee study area, the estimate of 71 bears (95% CI = 59–91) obtained from the individual heterogeneity model M_h was most appropriate for our data. We selected model M_h over the Jolly-Seber model A because the closed model required fewer assumptions and arrived at approximately the same estimate using only 2 parameters. Because fewer parameters were involved, precision was increased as a result of individual model assumptions being met. Similarly, we conclude that the estimate produced by the null model M_o of 44 bears (95% CI = 40–57) was most appropriate for the Osceola study area during 1999.

The estimated densities of black bears on the Okefenokee and Osceola study areas were 0.14 and 0.12 bears/km^2, respectively. Those estimates fell within the range of densities reported for other black bear populations throughout the southeastern U. S. (Table 50). Direct comparisons of population densities between areas, however, should be made with caution because of differences in spatial extent and estimation method. Because density estimates were almost the same for each of the study areas, however, the average between the Okefenokee and Osceola densities may provide a rough estimate of population size for bears in the larger area. Based on a weighted average density of 0.135 bears/km^2 and assuming a homogeneous distribution, we estimate that approximately 830 bears (95% CI = 707–1,045) inhabit the 6,147-km^2 Okefenokee-Osceola ecosystem.

Reproduction and Denning

The denning chronology of female bears on the Okefenokee and Osceola study areas was similar to that of other southeastern coastal black bear populations (Table 51). Our research supports other findings that pregnant females den earlier and for more extended periods than non-pregnant females and males (Hellgren and Vaughan 1989*a*, Weaver and Pelton 1994, Oli et al. 1997). Annual variation in the timing of den entry and emergence appear to have been influenced by food availability on both study areas. In 1996, when blackgum production was unusually abundant on the Okefenokee study area, females denned earlier (11 December) and for longer periods (112 days) than all other years. In addition, 99% (n = 69) of all documented cub births on the Okefenokee area in 1997 and 1999 following years when blackgum production was good. Likewise, Okefenokee females entered dens the latest (9 January) and remained for the shortest period (84 days) in 1995 when there was a blackgum failure. Interestingly, oak mast was unusually abundant in 1995 but did not appear to influence denning chronology or cub reproduction; only 1 of 15 solitary females produced cubs in 1996. Although relatively large stands of oak species were located during this study, they were patchily distributed and found primarily on remote interior islands of the Okefenokee Swamp. We suspect that the energy expended by female bears traveling between islands in search of oak mast counterbalanced the caloric intake from oak mast that was acquired. Consequently, den entry dates were delayed even in the presence of an energy-rich food supply. Our data indicate that cub production by female bears on the Okefenokee study area is in synchrony, brought on by abundant blackgum.

Unlike Okefenokee females, bears on the Osceola produced cubs each year of this study and we detected no synchronous reproductive patterns. We suspect the reason for higher cub production among Osceola females is because of the abundant supply of corn available to bears in the area. Adult bears on Osceola were approximately 19% heavier than those captured on Okefenokee. As a result, Osceola females generally were in better condition prior to den entry.

Population Modeling

Although our population simulations suggest overexploitation is occurring at current harvest levels at the Okefenokee study area, the simulations are of a closed population and, therefore, do not include immigration or emigration. Our data suggest that both occurred on the Okefenokee study area. Of our radiotagged bears, the average emigration rate over the 5 years of study was 0.13 (SD = 0.15). In 1999, however, none of the 25 bears that we monitored left the study area. This suggests a dispersal rate from the Okefenokee population that averaged 9.2 annually (based on a population estimate of 71 bears), and may have been as few as zero in 1999.

Conversely, Jolly-Seber models enabled us to estimate recruitment (B), which includes both births and immigration (Pollock et al. 1990). Given our simulation parameters, we can expect births to average about 16.6% of the population annually or about 11.8 cubs/year given our starting population size of 71. Model B estimated total recruitment in 1999 as 28 bears, thus we can expect that immigration would be approximately 16 bears (22%). Thus, these 16 immigrants were offset by an average loss of 9.2 emigrants each year, for a net gain of approximately 7 animals or 10%. Based on that, the average sustainable harvest of 5 bears (7%) that we calculated could be increased to approximately 12 (17%), which is greater than the average annual 1995–1999 harvest of 9.4 (13.2%). If the age distribution were stable, that rate would increase slightly (18%). We consider the harvest levels on the Okefenokee study area to be at the upper extreme relative to the overall harvested population in south Georgia. It appears that the harvest levels on the Okefenokee study area are sustainable, but not without the immigration that occurred.

On the Osceola study area, average annual population growth averaged 1.184, a high rate for the species (Bunnell and Tait 1981). Our mark-recapture data from Osceola suggested a high dispersal rate by subadult bears, and our population modeling data support that hypothesis. It appears that the feeders are responsible, in large part, for the high productivity of the Osceola bears. Consequently, young recruits disperse into surrounding habitat; we documented bears on the Okefenokee study area that originated from the Osceola study area but not the converse. Thus, our data suggest that immigration is crucial to the sustainability of the hunted portion of the overall bear population and that bears from within the ONWR and Florida provide these surplus immigrants. Furthermore, it appears that the level of immigration is positively influenced by the presence of deer feeders in Florida.

Reproductive synchrony was predicted by our simulations for both populations, but with a greater amplitude and duration on the Okefenokee study area (Fig. 23). This was most likely the result of more stable food resources on the Osceola area, again due to the deer feeders. Additionally, the average age of Osceola bears declined over time as a result of high recruitment in this expanding population. This illustrates the fallacy of using decreasing average ages as an indicator of overexploitation (Clark 2002).

Food Habits

One of the most significant findings of this study is the effect of varying availability and abundance of food on black bears in the Okefenokee Swamp-Osceola ecosystem. Bears on the Okefenokee study area were heavily dependent on shrub/vine and blackgum fruit. Whereas palmetto fruit dominated the overall volume of bear diet on Okefenokee, fluctuations in annual abundance of the fruit were common. Even in years of moderate abundance, palmetto fruit was patchily distributed throughout the study area. As a result, bears tended to exhibit an increase in movements during years when palmetto was less abundant. The higher amount of corn we found in stomachs compared to scats from Okefenokee likely was the result of illegal baiting during the hunting season.

Although blackgum abundance also fluctuated on the Okefenokee area, production was more consistent and it appeared to occur on a biennial cycle. Furthermore, our telemetry data indicate that, in years of abundant blackgum production, bears retreated to these areas and remained until the onset of denning. During the heavy crop of blackgum in 1996, only 1 of 22 radiocollared females traveled outside of ONWR after mid-October. More importantly, we observed high reproductive success in 1996, with 21 of 22 radiocollared females producing cubs. This is a striking contrast to 1995 when, during a blackgum shortage, only 1 of 15 radiocollared females produced cubs. Females were still in reproductive synchrony at the conclusion of this study in 1999, indicating a strong positive relationship between blackgum and cub production in and around ONWR.

For Osceola, however, the abundance and availability of palmetto fruit and corn most influenced bear diets. Although our data suggest Osceola bears may prefer palmetto fruit to corn, the abundance of deer feeders make corn the most readily available food item on this area. Corn provides Osceola bears with a readily available, high quality food during times of natural food shortages. In contrast, bears on the Okefenokee area relied almost exclusively on natural foods. The buffer that corn provided was the likely reason for higher reproductive output among Osceola females, reflected mostly in the proportion of eligible females producing cubs. Based on our data, the overall probability of females $\geq$3 years old having a litter was 0.917 on the Osceola study area and that rate was fairly consistent from year to year. In contrast, the probability of producing a litter for Okefenokee females was 0.517, but that average ranged from almost no cub production during years of food shortage to nearly 100% during years of food abundance. Other researchers also have found strong relationships between food and cub production (Rogers 1976, Elowe and Dodge 1989, McDonald and Fuller 2001).

Home Range Analysis

Estimates of annual home range size for Okefenokee bears during this study were larger than those reported from most black bear populations in North America (Table 52). In contrast, home range estimates for females Osceola were significantly smaller than Okefenokee and fell within the range of other bear populations. Whereas factors such as age, sex, and reproductive status influence spatial characteristics of black bears (Pelton

1982), food availability and abundance appears to be the primary reason for differences in home range size and shape between the Okefenokee and Osceola areas. The annual diet of Okefenokee bears was volumetrically dominated by blackgum (32%) and palmetto fruit (25%). During this study, the abundance of both of those foods fluctuated drastically between years and often was patchily distributed throughout the area. As a result, home ranges on Okefenokee included relatively large areas as bears were forced to seek out those natural foods. In contrast, bears on the Osceola area were much less reliant on natural foods because of the readily available and abundant supply of corn from deer feeders. Amstrup and Beecham (1976) suspected that because female bears are not burdened with the energetic expense of seeking out mates, home ranges need only be large enough to supply adequate resources for daily survival and production. Based on the similarity of habitats within the 2 areas, and because corn accounted for 37% of the annual diet of Osceola bears compared to <5% on Okefenokee, it appears that corn from deer feeders enabled Osceola bears to meet their nutritional requirements within substantially smaller home ranges. The value of the feeders is further evidenced by Osceola females being approximately 19% heavier than those on Okefenokee with higher cub production rates.

Not surprisingly, we detected no difference between seasonal home range sizes for female bears on the Osceola study area. For Okefenokee females, however, the reliance on natural foods appeared to influence the size and location of seasonal home ranges. During summer, foods were usually patchily distributed and often were available only for relatively short periods of time. Consequently, bears foraged over larger areas to meet their nutritional needs (Reynolds and Beecham 1976). Bears also were located more frequently in upland habitats during the summer, likely in search of various shrub/vine fruits. During fall, female home ranges on Okefenokee were smaller when food items were more abundant. We observed exceptions to this, however, during years when blackgum production was less than moderate. The most extreme case of seasonal home range expansion occurred during fall 1999 following an abundant blackgum crop in 1998 when average fall home range size increased from 14.5 km^2 to 78.4 km^2 for Okefenokee females. We also observed an unusually abundant crop of palmetto fruit in 1999 that remained available throughout the fall. Consequently, many radiocollared females expanded their home ranges into upland habitats away from ONWR during that time (Fig. 32). As a likely result, 5 females were harvested on the Okefenokee study area during the 1999 bear-hunting season. That was a dramatic increase considering that only 7 females were harvested on the study area from 1996 to 1998.

Home range overlap of bears on the Okefenokee study area appeared to be primarily influenced by a combination of food availability and proximity to ONWR. Whereas annual ranges tended to be centered around blackgum habitat, they were usually situated along the refuge boundary adjacent to upland habitats. This type of spatial distribution provided bears with access to important summer and fall food resources, while minimizing distances traveled from ONWR. Considering that bears can be chased with dogs for almost the entire year in areas around ONWR, this disturbance may inhibit females from extending annual ranges further into upland habitats. On the Osceola study area, home range overlap was as extensive but appeared to be concentrated within upland pine habitats where deer feeders were found.

Movement Patterns and Microhabitat Use

When the habitat use data were analyzed using the four cover types that represented the majority of the study area, results were only significant for the Rest category. There was minimal overlap in the multiple comparisons between cover types within the Rest category. Therefore, we conclude that female black bears in on Osceola prefer Wetland Mixed Forests to Pine Plantations for resting.

Because habitat use was based on the proportion of cover types present within each movement category, the size of the buffered area surrounding each movement event likely influenced the usage component of the test. The Forage, Search, and Travel categories comprised mostly active locations as well as longer movements between locations. Consequently, the areas used for the habitat analysis in these categories were larger than the areas in the Rest category. Therefore, the results may not have been significant because within those larger areas, there was a greater probability that the various cover types would be well represented and thus use would appear to be even. For example, it was not surprising that there were no differences in habitat use in the Travel category, as the movements in that category covered great distances (up to 5 km between locations). The cover types present in the study area were interspersed, and with such long distance travel movements, there was a greater chance for all habitat types to be included as “used” in the analysis. Female home ranges in this study greatly overlapped, and we observed an extensive network of paths created by bears throughout the area. Thus, with a landscape interspersed with many habitat components, any disproportionate use for traveling might be masked.

Even though the statistical results for the habitat use analysis were inconclusive for all but the Rest category, the habitat rankings alone provide valuable information on the importance of the various types. The rankings reflect the greater proportion of a particular cover type that bears were most often in or were close to while engaging in 1 of the 4 movement patterns. The results show high use for Wetland Mixed Forest habitat type as it ranked high in all the movement categories. The more active categories of Foraging and Searching revealed that the Forest Regeneration component was ranked highest. This suggests that the younger pine stands were more important for food production.

Although Pine Plantation did not rank high for habitat use, bears still spent a great deal of time in that type. From our scat analyses, nearly all of the foods present in bear scats at Osceola came from the Pine Plantation cover type. Together, the scat data and the habitat use results suggest that food was plentiful in Pine Plantations and bears spent little time searching for and procuring food while there. Bears that moved into Pine Plantations to feed, did so quickly and efficiently, and then moved back to wetland areas. A significant dietary component of Osceola bears was corn, and the deer feeders were located mostly in Pine Plantations. Bears would have to spend little time at those feeders, which is consistent with our habitat use findings. However, natural foods also were abundant in Pine Plantations, especially palmetto berries. Again, bears may not need to forage long on palmetto berries to obtain sufficient quantities. Because foraging may take relatively little time, the importance of pine plantations may have been underemphasized in our study. Conversely, the value of those habitats was increased artificially because of the deer feeders.

Black bears on Osceola sought out wetland habitat despite its increasing rarity. Similarly, in western Florida, Stratman and Pelton (1999) found frequent signs of bears feeding on palmetto near rivers, streams, and wetlands during the spring and summer in

Eglin Air Force Base. In the Fakahatchee Strand in south Florida, Maehr (1996) concluded that black bears used mixed swamp in higher proportion than was available. Our study area was comprised almost exclusively of private timberlands and had few riparian areas. Old topographical maps show extensive wetlands throughout the study area. Today, in many places on the study site, the wetlands have been replaced with pine, resulting in a patchy distribution and representing a smaller proportion of the landscape.

Macrohabitat Use

Habitat use by female bears on both study areas was disproportional to availability at second- and third-order levels of selection. On the Okefenokee study area, the spatial distribution of loblolly bay and gum/bay/cypress habitats appeared to be the primary influence on where bears established home ranges. Nevertheless, radiocollared bears on Okefenokee always established home ranges within close proximity to upland pine habitats (Figs. 29 and 30). Even in the case of bears that rarely traveled outside ONWR, their activity centers were concentrated around interior islands of the swamp. Like the upland habitats, those islands were higher in elevation than the surrounding swamp and were characterized by mesic pine communities. Both upland pine habitats and interior islands provided seasonal foods such as saw palmetto berries that were not available in loblolly bay or blackgum/bay/cypress habitats. Considering that palmetto berries accounted for 25% of the annual diet of bears on Okefenokee, pine habitats appear to be an important influence on bear distribution within ONWR.

Okefenokee females selected gum/bay/cypress or loblolly bay habitats above other habitat types at the third-order level. The importance of gum/bay/cypress habitats appears to be primarily related to food availability, as blackgum mast accounted for 32% of the annual diet of Okefenokee bears. In contrast, the heavy use of loblolly bay forests appears to be related to its general connectivity to gum/bay/cypress habitats and upland pine. On the Okefenokee study area, loblolly bay forests were the primary interface between upland pine habitats and the interior of ONWR. As such, travel between upland pine and blackgum habitats resulted in bears spending considerable amounts of time in loblolly bay forests. This is supported by our analysis of microhabitat preference on the Osceola area, which indicated that bears use wetland mixed forests when moving between areas. Because these loblolly bay habitats formed a distinct separation between the ONWR boundary and private lands, they also provided important escape cover from hunters during the fall and from dogs during the chase season. Our findings were similar to other studies that have demonstrated the importance of swamps and other wetland forest habitats to bears in the southeastern coastal plain (Hamilton 1978, Mykytka and Pelton 1990, Hellgren and Vaughan 1994, Wooding and Hardisky 1994, Stratman 1998).

Although pine habitats were used less than expected on the Okefenokee area, 57% of the summer diet of Okefenokee bears was comprised of food items (i.e., huckleberry, blueberry, sweet gallberry) found almost exclusively in pine. Likewise, saw palmetto fruit accounted for 37% of the fall diet during this study. The importance of pine habitats may have been underrepresented by our compositional analysis. We suspect this apparent discrepancy was the result of a temporal sampling bias associated with the telemetry data. Our daytime radiolocations may have been collected during a time when Okefenokee bears were inactive and less prone to be found in upland pine habitats. Additionally, our microhabitat use data indicated that bears on the Osceola area minimized time spent feeding in pine plantations by foraging quickly and efficiently on preferred food items, then returning to wetland areas. We suspect that bears on Okefenokee used pine plantations in much the same way, especially considering the added pressures of a year-round chase season there.

Use of swamp forest habitat by Okefenokee bears was significantly greater when we examined habitat selection within home ranges. Unlike the Osceola study area, there was an abundance of creeks and drainages on the Okefenokee area. Classified as swamp forest habitat, we suspect that these riparian zones served as important travel corridors to and from ONWR. On Eglin AFB in Florida, riparian zones were found to be the primary habitat type used by bears (Stratman 1998). In our study, local hunt club members indicated that most chases resulted in bears using creek drainages to return to ONWR. Although swamp forests were widely interspersed and accounted for only 12.3% of the study area, this habitat appears to provide important escape cover and relatively secure routes of travel through upland pine habitats.

On the Osceola study area, female bears were more prone to establish home ranges in areas with blackgum/bay/cypress habitats and pine. Although blackgum/bay/cypress ranked high in use for both areas, it represented only 10.8% of available habitat types in Osceola. The heavy use of pine on Osceola may be because that type made up 40.1% of the study area and was widely dispersed. Consequently, female home ranges on Osceola generally contained large proportions of pine habitat. Unlike Okefenokee, loblolly bay forests in Osceola ranked only moderately in terms of home range placement, and were used significantly less than swamp forest habitats. Loblolly bay habitat in the Osceola study area was mostly found along the periphery of study area boundaries (Fig. 11), which may have affected usage. As was the case on Okefenokee, shrub wetlands did not seriously influence bear distribution at the second-order of habitat selection.

Our analysis of habitat use for Osceola females at the home-range level produced results that were quite different from the second-order analysis. The first distinction was that blackgum/bay/cypress and swamp forest habitats were selected for above all other habitat types. In contrast, pine plantations ranked fifth in use among the 7 available habitat types. This was surprising considering that 45% of the annual diet of Osceola bears came from fruit-bearing plants found almost entirely within pine habitats. Likewise, corn from deer feeders accounted for an additional 37% of their annual diet, and all feeders were located in pine plantations.

Unlike the Okefenokee area, upland pine habitats on Osceola were not distinctly separated from wetland and swamp habitats. Rather, wetland forests occurred as a matrix of relatively small bays and blackgum swamps interspersed throughout pine plantations. Osceola bears appeared to use blackgum/bay/cypress and swamp forest habitats because they offered excellent cover, and provided easy access to food resources located in nearby pine. From our analysis of microhabitat use, bears spent over twice as much time in wetland mixed forests (607 h) as they did in pine plantations (253 H), yet tended to remain in relatively close proximity to pine habitats. Although Osceola bears spent more time in blackgum/bay/cypress habitats, blackgum mast accounted for <5% of the annual diet on Osceola every year except 1998.

Loblolly bay forests and shrub wetlands also ranked higher in use than pine plantations. Whereas loblolly bay forests likely were used for reasons similar to blackgum and swamp forests, shrub wetlands generally were not located near pine plantations and were almost devoid of bear foods. During this study, however, 100% (*n*

= 37) of documented den sites on the Osceola area were located in these dense shrub habitats. We suspect that, whereas these habitats were not extensively used throughout the year, they provided a valuable resource to Osceola bears during winter months and as escape cover.

Bears and Beeyards

Of the 28 bears that had annual home ranges encompassing beeyards, only 4 (3M:1F) were known to have caused nuisance problems. Many bears had access to beeyards and did not cause damages. We noticed a bear trail near almost every beeyard in the study area, yet most beeyards were never damaged by bears. Presumably, bears were attracted to the yards but were prevented from entering by the electric fences. Bears may regularly check the status of these fences; indeed, all instances of bear depredation occurred shortly after batteries that powered electric fences expired.

Beeyards that were near roads and riparian zones were more likely to be damaged by bears. Bears on the study area used habitats adjacent to both roads (most of which were closed) and streams and they probably serve as important travel corridors. Similar findings relating corridor use and beeyard depredation have been reported elsewhere (Gunson 1973, Merrill 1978). Beeyards that are located in areas more likely to be frequented by bears are at greatest risk.

Initial results of trapping and subsequent release of nuisance bears at beeyards in Florida suggested that the technique was successful in deterring problem bear behavior (Brady and Maehr 1982, Wooding et al. 1988). Of the 7 nuisance bears that we radiocollared, 2 resumed nuisance activity indicating that the release technique was not totally effective. Several factors may affect the success of trap and release of nuisance bears. First, we were never sure that the bear we captured was the bear that had caused the damage. Our average time before capture was 4 days, and we left traps set at beeyards for up to 7 days. Bears are highly mobile and there was ample opportunity to capture non-nuisance bears. Also, there was a time lag between damage and acknowledgement of damage. Beekeepers on our study area checked their yards about every 3 days and additional time would elapse before the bear was captured. If we captured the offending individual, such time lags may diminish the negative association of capture and release with the behavior we are attempting to prevent, i.e., beeyard damage. Finally, many of the beeyards that were damaged were not revisited by bears; those individuals could then raid additional yards.

Relocation has long been used as a tool to manage nuisance bears. An increasing number of studies have concluded that relocation, sometimes of even lengthy distances, does little to prevent the return of the offending animals (Payne 1975, Rutherglen and Herbison 1977, Rogers 1984). Two nuisance bears were relocated to remote portions of ONWR during our study; both returned to reestablish their home ranges.

Beekeepers that responded to our survey would prefer to reduce the bear population as a whole with chemicals, trapping, or shooting, and most did not employ electric fences to deter bears. Those that had used electric fences, however, deemed them effective. In contrast, most if not all the beekeepers on our study area used electric fences because of high bear densities. If kept charged, those fences were an effective deterrent to bear predation of beeyards, even when beeyards were in good bear habitat and visited regularly by bears.

CONCLUSIONS

Although the estimated densities of bears were similar between the Okefenokee and Osceola study areas, other aspects of population dynamics represent opposite ends of the spectrum. On Osceola, protection from hunting has resulted in high population growth and a high emigration rate of among subadults. However, based on observed differences in weight, home range dynamics, and reproductive rates compared to bears on Okefenokee, population growth appears to have been further spurred by the many corn feeders on Osceola. From 1997–1998, 18 (43%) of the 42 untagged bears that were live-captured on the Osceola study area were subadult males. However, only 3 of those subadults were ever captured again; 1 bear from 1997 was recaptured in 1998 and the other 2 were identified at hair traps in 1999. Those low recapture rates suggest that a high proportion of subadult males may be dispersing from the Osceola area. Indeed, 2 bears that were initially caught on the Osceola study area in 1996 were harvested on the Okefenokee study area in 1996 and 1999. In each of those cases, bears were subadult males that had traveled >50 km from their last capture location on the Osceola study area.

Conversely, on the Okefenokee study area, mortality from hunting is high but sustainable because of the constant influx of immigrants. We speculate that bears from refugia within ONWR, and to some extent Florida, serve to fuel the high population turnover caused by hunting mortality in the surrounding Georgia counties. That harvest is mitigated by the production of blackgum, which makes bears less vulnerable during high-production years. In poor years, bears are forced to forage on upland areas for palmetto and gallberry, and are extremely susceptible to harvest by hunters. Thus, Florida and ONWR may be serving as important sources for bears with hunted areas serving as sinks.

A major component of bear management surrounding the Okefenokee Swamp will involve harvest regulation. The Black Bear Management Plan for Georgia (Georgia Department of Natural Resources 1999) calls for a maximum harvest rate of 20% with females comprising no more than 50% of the harvest. The maximum sustainable harvest may be lower; our simulation modeling indicated that maximum sustainable yield, given a stable age distribution, was about 18% which assumes immigration from a source population occurs. Harvest rates for radiocollared males and females were 22% and 8% on the Okefenokee study area, respectively. By extrapolating our density estimates from the Okefenokee study (0.14 bears/km^2) across the 1,580-km^2 ONWR, 20% of this population would be approximately 44 bears. Since 1984, however, that goal has not been reached on average; the annual bear harvest for the 5 counties contiguous with the Okefenokee Swamp has averaged 35 bears. We caution against increasing bear hunting opportunities at this time. Harvest levels have fluctuated annually and our radiotelemetry data indicate that during periods of blackgum scarcity, bears make use of upland habitats and, when they do so, stand a high chance of being killed by hunters. Consequently, harvests can be expected to continue to fluctuate and should be designed to accommodate those extremes. Because black bears have such low reproductive potential (Pelton 1982), an excessively large harvest of females could depress bear numbers for years to come. Our population estimates were for 2 relatively small subunits of the Okefenokee-Osceola ecosystem. Differences in those densities elsewhere in the area could greatly affect those density extrapolations and, consequently, sustainable yield.

In the absence of a hunting season, bear numbers on the Osceola area may have reached a biological or social threshold resulting in high dispersal rates for subadult males. Management efforts should be oriented towards identifying and protecting habitat connections between Osceola NF and ONWR. Future research should target dispersal, movement patterns, and survival of subadult males. The resultant data could then be used identify habitat serving as linkage zones between the Osceola and Okefenokee areas.

Clearly, bears in the Okefenokee-Osceola ecosystem could not survive without the security provided by the swamp itself. Few bears lived year-round on the Okefenokee study area without making use of swamp habitats. On the Osceola study area by contrast, bears made extensive use of upland habitats but that was heavily influenced by the corn feeders. Even so, riparian habitats were critical on the Osceola area and bears seemed to prefer natural foods when they were available. Despite their reliance on wetlands, upland habitats were also important to bears for soft mast production (e.g., palmetto and gallberries), particularly during periods of blackgum scarcity. Private lands were particularly important for providing such upland soft mast. The increased use of herbicides on private land for timber management could have negative consequences for bears by reducing or eliminating such upland soft mast foods. Additionally, more frequent burning rotations to promote longleaf pine-wiregrass ecosystems could have a similar effect. It is important to monitor changes in bear foods in habitats where these management practices have been effected.

Man is a critical element in black bear population dynamics in the Okefenokee-Osceola ecosystem; where bears are not tolerated by man, they do not exist. Our data suggest that working electric fences are an effective deterrent to bear damage to beeyards, even in areas frequented by bears. Given proper maintenance, electric fencing should prevent almost all nuisance bear problems in and adjacent to our study areas. Most of the respondents to our survey did not employ electric fencing to prevent bear damage, yet most had experienced damages by bears. Most beekeepers relied on often more expensive, less effective, and, perhaps, illegal methods to protect their beeyards. Trapping and relocation by management authorities was heavily relied upon by beekeepers but was often ineffective. Additionally, the location of beeyards can affect nuisance activity; placing beeyards away from riparian corridors and, to some extent, roads may help alleviate potential problems with bears. Beekeepers in southeast Georgia and north Florida should be better informed about new techniques (e.g., solar chargers, inexpensive fencing designs) that can almost eliminate bear damages to their yards.

Hunting is an important recreational activity in the region and it has significant impacts on the bear population as well. However, if properly regulated, hunting and training bear dogs adds value to bears and helps garner local support for their management. In Florida where bears are no longer hunted, locals often viewed them as a liability rather than an asset. Viewpoints by locals in Georgia were more positive. Finally, bears have significantly benefited from the deer baiting that takes place in Florida. Should that practice suddenly cease, negative consequences to the local bear population would surely result. The carrying capacity of Osceola habitats has probably been artificially increased by the deer feeders.

Although the Okefenokee-Osceola bear population is relatively large and clearly not in jeopardy, the long-term persistence of other Florida black bear populations is more questionable. Habitat loss and fragmentation and human encroachment are resulting in populations that are becoming increasingly isolated from other bear populations. Of the 7 recognized Florida black bear populations, the USFWS has concluded that only the Apalachicola NF, Ocala NF, Big Cypress National Preserve, and Okefenokee-Osceola ecosystem populations are viable (Bentzien 1998). In contrast, the Chassahowitzka bear population, located on the central Gulf Coast of Florida, may contain <20 individuals (Bentzien 1998) and the south Alabama population may number fewer than 30 (Edwards 2002). For these smaller, more isolated populations to persist into the foreseeable future, it may be necessary to augment them with bears from one of the larger populations. If augmentation were to be considered as a management option, the donor population must be able to withstand the loss of some bears, presumably adult females (Eastridge and Clark 2001). Bears from the Okefenokee-Osceola ecosystem could be candidates for such translocations.

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Table 1. Cover type classifications used for analysis of microhabitat use for black bears on the Osceola study area, Florida, 1999.

Cover Type	Abbrev.	Description
Forest regeneration	FR	These are cut over pine forests where it is evident that harvested stands will be reforested through silvicultural practices rather than allocated for another land use or abandonment. This may also include recently planted pines.
Pine plantations	PP	Pine forests intensively managed for wood and fiber production.
Temperate hardwoods	TH	Mesic hammock forest dominated by hardwoods with pines as minor associates. Common components of this community may include a wide variety of oaks, red bay, sweetbay, magnolia, sweetgum, sugarberry, hickories, cabbage palm, hollies, and cedar. The combinations of these species are dependent upon location.
Mesic flatwoods	MF	Pine flatwoods dominated by slash pine, longleaf pine, or both. The understory species include saw palmetto, wax myrtle, gallberry, and a wide variety of shrubs, grasses, and herbs. The canopy is exclusively pine and somewhat open.
Wetland mixed forest	WMF	Includes mixed wetlands forest communities in which neither hardwoods nor cypress dominate the canopy. This classification contains combinations of bay, cypress, and gum species.
Wet flatwoods	WF	A pocosin-type wet flatwoods, which usually has a shrubby understory with invading bays and hardwoods.
Cypress	CY	Swamps clearly dominated by cypress, which makes up 90% or more of the canopy.
Bay swamps	BS	This category is composed of dominant trees such as loblolly bay, sweetbay, red bay, swamp bay, slash pine, and loblolly pine. Large gallberry, fetterbush, wax myrtle, and titi are included in the understory vegetation.
Shrub swamps	SS	Composed of dense stands of black titi and cyrilla. Associated species include bays, cypress, tupelos, and a great variety of wetland hardwoods. SRWMD required 90% or more shrub cover and no more than 10% tree canopy.
Improved pasture	IP	Composed of land which has been cleared, tilled, reseeded with specific grass types, and periodically improved with brush control and fertilizer application.

Table 2. Habitat components available to black bears on the Osceola study, Florida, 1999.

Cover type	% Available	Overall %
Improved pasture	0.2	
Other shrubs and brush	0.4	
Bay swamp	1.3	
Mesic flatwoods	0.3	6.6
Temperate hardwoods	1.0	
Shrub swamp	2.3	
Cypress	1.1	
Wetland mixed forest	27.5	
Pine plantations	43.5	
Wet flatwoods	12.7	93.4
Forest regeneration	9.7	
Total	100.0	100.0

Table 3. Habitat availability used for compositional analysis of second and third-order selection by female black bears on the Okefenokee and Osceola study areas, Georgia and Florida 1996–1999.

	Okefenokee		Osceola	
Habitat type	Area (km^2)	%	Area (km^2)	%
Blackgum/bay/cypress	243.6	30.0	40.6	10.8
Loblolly bay	160.2	19.7	53.2	14.1
Pine/oak	52.2	6.4	11.1	2.9
Pine	223.4	27.5	151.0	40.1
Swamp forest	99.8	12.2	68.6	18.2
Shrub wetlands	24.2	3.0	44.1	11.7
Disturbed	9.9	1.2	8.3	2.2
Total	813.3		376.9	

Table 4. Trapping summaries for the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1998.

Study area, year	Number of bear: Visits	Number of bear: Captures	Trapnights	Trapnights per capture	Success rate[a] (%)	Capture rate[b] (%)
Okefenokee						
1995	135	78	1,331	17.1	5.9	57.8
1996	57	33	1,581	47.9	2.1	57.9
1997	200	49	1,691	34.5	2.9	24.5
1998	418	53	1,822	34.4	2.9	12.7
Total	810	213	6,425	30.2	3.3	26.3
Osceola						
1996	48	39	1,454	37.3	2.7	81.3
1997	107	48	1,829	38.1	2.6	44.9
1998	418	45	1,828	40.6	2.5	10.8
Total	573	132	5,111	38.7	2.6	23.0
Grand total	1,383	345	11,536	33.4	3.0	24.9

[a] Success rate is the number of bear captures divided by the number trapnights.
[b] Capture rate is the number of bear captures divided by the number bear visits.

Table 5. Sex ratios and chi-square tests for equal proportions for black bears captured on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1998.

Study area, year	*n*[a]	Sex ratios (M:F) Number	Sex ratios (M:F) Proportion	?^{2} -value	*P*-value
Okefenokee					
1995	78	48 : 30	1.6 : 1	4.15	0.042
1996	33	16 : 17	0.9 : 1	0.03	0.862
1997	49	38 : 11	3.5 : 1	14.88	<0.001
1998	53	35 : 18	1.9 : 1	5.45	0.020
Total	213	137 : 76	1.8 : 1	17.47	<0.001
Osceola					
1996	39	24 : 15	1.6 : 1	2.08	0.150
1997	48	29 : 19	1.5 : 1	2.08	0.149
1998	45	25 : 20	1.3 : 1	0.56	0.456
Total	132	78 : 54	1.4 : 1	4.36	0.037
Grand total	345	215 : 130	1.7 : 1	20.94	<0.001

[a] Sample size for age is different than captures because some bears did not have a tooth removed for aging due to tooth loss or premature recovery from sedation.

Table 6. Sex ratios by age class and chi-square tests for equal proportions for black bears captured on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1998.

Study area, year	n[a]	Sex ratios (M:F) Number	Sex ratios (M:F) Proportion	?^{2} -value	P-value
Okefenokee					
Yearling	28	24 : 4	6.0 : 1	14.29	<0.001
2-yr	40	33 : 7	4.7 : 1	16.90	<0.001
3-yr	32	22 : 10	2.2 : 1	4.50	0.034
Adult	113	58 : 55	1.1 : 1	0.08	0.778
Osceola					
Yearling	32	20 : 12	1.7 : 1	2.00	0.157
2-yr	16	12 : 4	3.0 : 1	4.00	0.046
3-yr	26	18 : 8	2.3 : 1	3.85	0.050
Adult	58	28 : 30	0.9 : 1	0.07	0.793

[a] Sample size for age is different than captures because some bears did not have a tooth removed for aging due to tooth loss or premature recovery from sedation.

Table 7. Age (years) distributions of black bears captured on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1998.

Study area,	Females				Males			
year	*n*	$\bar{x}$	SE	Range	*n*	$\bar{x}$	SE	Range
Okefenokee								
1995	27	5.1	0.49	2–10	39	4.0	0.56	1–10
1996	14	5.6	0.54	3–11	13	5.1	0.98	1–11
1997	10	5.0	0.61	2–9	28	3.0	0.44	1–11
1998	17	5.1	0.85	1–13	32	3.7	0.43	1–12
Total	68	5.2	0.32	1–13	112	3.8	0.24	1–12
Osceola								
1996	15	3.5	0.43	1–7	21	2.9	0.35	1–6
1997	15	4.3	0.80	1–10	26	4.0	0.56	1–13
1998	17	4.6	0.70	1–11	20	3.6	0.49	1–8
Total	47	4.2	0.38	1–11	67	3.5	0.29	1–13
Grand total	115	4.8	0.25	1–13	179	3.7	0.18	1–13

Table 8. Mean masses (kg) of black bears captured on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1998.

Study area,	Females				Males			
year	*n*	$\bar{x}$	SE	Range	*n*	$\bar{x}$	SE	Range
Okefenokee								
1995	27	49.1	1.41	34.1–63.6	39	77.2	4.96	34.1–159.1
1996	16	55.4	3.21	40.9–79.5	13	86.2	8.82	38.6–129.5
1997	11	57.0	3.85	36.4–86.4	28	86.9	7.17	36.4–181.8
1998	17	50.8	4.51	22.7–102.3	32	79.5	5.59	22.7–136.4
Total	71	52.1	1.54	22.7–102.3	112	81.3	3.11	22.7–181.8
Osceola								
1996	14	54.6	4.06	25.0–77.3	21	87.7	10.19	25.0–181.8
1997	15	60.0	4.48	40.9–97.7	26	100.2	6.64	38.6–163.6
1998	16	50.3	4.21	25.0–77.3	20	94.4	11.44	25.0–181.8
Total	45	54.9	2.48	25.0–97.7	67	94.5	5.29	25.0–181.8
Grand total	116	53.2	1.35	22.7–102.3	179	86.3	2.81	22.7–181.8

Table 9. Mean masses (kg) by age class for black bears captured on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1998.

Study area,	Females			Males		
age class	*n*	$\bar{x}$	SE	*n*	$\bar{x}$	SE
Okefenokee						
Yearlings	3	25.0	1.31	22	46.2	3.03
2-yr	7	44.5	3.32	25	63.0	3.55
3-yr	13	48.8	2.02	18	69.2	3.74
Adult	53	55.0	1.71	53	110.7	4.31
Osceola						
Yearlings	10	37.3	4.42	14	43.2	4.20
2-yr	4	44.3	3.28	10	69.1	8.24
3-yr	7	54.9	4.50	17	92.3	6.99
Adult	24	63.9	2.68	26	133.5	5.31

Table 10. Sources of mortality for black bears in the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1999.

Study area	Sex	Harvest	Illegal harvest	Natural	Vehicle	Nuisance
Okefenokee						
1995	F	3	0	0	1	0
	M	13	1	0	0	0
1996	F	6	0	2	0	0
	M	4	0	0	0	0
1997	F	1	0	1	0	0
	M	12	0	0	0	0
1998	F	1	0	0	0	0
	M	11	0	0	1	1[a]
1999	F	5	0	0	0	0
	M	12	0	0	0	0
Total	F	16	0	3	1	0
	M	52	1	0	1	1
Osceola						
Total	F	0	2[c,d]	0	0	0
	M	2[b]	0	0	1[e]	0

[a] Male bear 85 removed from population in July 1998 for beeyard depredation.

[b]Two male bears originally captured on Osceola were harvested on Okefenokee in 1996 and 1999.

[c] Female bear 227 killed by a bowhunter on first day of archery season for deer in 1997.

[d] Female bear 205 and her 2 female cubs shot over a corn pile in December 1999.

[e] Male bear 276 struck by a vehicle in June 1999.

Table 11. Sources of mortality for radiocollared bears in the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1999.

Study area	Sex	Harvest	Illegal harvest	Natural	Vehicle	Nuisance
Okefenokee						
1995	F	1	0	0	1	0
	M	1	0	0	0	0
1996	F	2	0	2	0	0
	M	2	0	0	0	0
1997	F	0	0	1	0	0
	M	1	0	0	0	0
1998	F	1	0	0	0	0
	M	1	0	0	0	1[a]
1999	F	3	0	0	0	0
	M	0	0	0	0	0
Total	F	7	0	3	1	0
	M	5	0	0	0	1
Osceola						
Total	F	0	2[b,c]	0	0	0
	M	0	0	0	0	0

[a] Male bear 85 removed from population in July 1998 for beeyard depredation.
[b] Female bear 227 killed by a bowhunter on first day of archery season for deer in 1997.
[c] Female bear 205 and her 2 female cubs shot over a corn pile in December 1999.

Table. 12. Estimated survival rates for female black bears on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1999.

	Okefenokee study area			Osceola study area		
Year	*n*[a]	Survival rate	95% CI	*n*	Survival rate	95% CI
1995	26	---	---	---[b]	---	---
1996	29	0.84	0.70–0.98	12	---	---
1997	28	0.94	0.83–1.00	20	0.92	0.80–1.00
1998	27	0.95	0.85–1.00	23	1.00	---
1999	19	0.79	0.61–0.97	20	0.93	0.81–1.00
Overall	129	0.87	0.80–0.93	75	0.97	0.92–1.00

[a] Sample size (*n*) = number of radiocollared bears at risk at the beginning of a time period plus the number of radiocollared bears added during that period.
[b] Trapping did not begin on the Osceola study area until summer 1996.
[†] Overall survival for Okefenokee males was 0.70 (95% CI = 0.53–0.88); male bears were not radiocollared on the Osceola study area.

Table 13. Sources of mortality for black bears harvested on the Okefenokee study area, Georgia, 1995–1999.

Year	Method of harvest			Total
	Dog	Still	Unknown	
1995	16	0	0	16
1996	8	1	1	10
1997	9	4	0	13
1998	10	1	0	11
1999	13	4	0	17
Overall	56	10	1	67

Table 14. Mean masses (kg) of black bears harvested on the Okefenokee study area, Georgia, 1995–1999.

Year	Sex	*n*	$\bar{x}$	SE
1995	Female	3	60.6	6.60
	Male	13	103.0	8.02
1996	Female	5	71.6	11.07
	Male	4	112.5	13.30
1997	Female	1	72.3	---
	Male	11	123.6	12.76
1998	Female	1	88.7	---
	Male	10	112.3	6.95
1999	Female	5	67.7	6.87
	Male	12	97.2	13.27
Overall	Female	15	69.6	4.56
	Male	50	108.8	5.04

Table 15. Sex ratios and chi-square tests for equal proportions for black bears harvested on the Okefenokee study area, Georgia, 1995–1999.

Year	*n*	Sex ratios (M:F)		?^{2} -value	*P*-value
		Number	Proportion		
1995	16	13 : 3	4.3 : 1	6.25	0.0124
1996	10	4 : 6	0.6 : 1	0.40	0.5271
1997	13	12 : 1	12 : 1	9.31	0.0023
1998	11	10 : 1	10 : 1	7.36	0.0067
1999	17	12 : 5	2.4 : 1	2.88	0.0896
Total	67	51 : 16	3.2 : 1	18.28	<0.0001

Table 16. A summary of the availability of radiocollared bears to hunting mortality on the Okefenokee study area, Georgia, 1995–1999.

Year	Radio days[a]	Radio-days available to harvest[b]	Number of bears available to Still hunting	Number of bears available to Dog hunting	Number harvested
1995	81	28	10	19	2
1996	172	36	17	19	4
1997	160	37	9	28	1
1998	121	12	0	13	2
1999	119	23	4	18	2[c]
Total	653	136	40	97	11

[a] Defined as the total number of days that bears were monitored during each annual 6-day hunt.
[b] Defined as the total number of days that individual bears were monitored and available for harvest.
[c] Excluding 1 radiocollared female that was harvested outside the study area during a 3-day hunt on Dixon Memorial State Forest.

Table 17. Summary statistics for successful bear harvests with the aid of dogs, Okefenokee study area, Georgia, 1995–1999.

Year	Number of hunters		Number of dogs		Length (km)		Duration (hrs)	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
1995	9.3	1.2	5.5	0.61	3.7	0.71	1.1	0.20
1996	18.1	1.65	10.0	1.56	2.6	0.42	1.6	0.26
1997	18.9	2.15	6.0	1.12	2.2	0.56	0.8	0.20
1998	12.0	2.16	6.1	0.78	2.8	1.49	0.8	0.25
1999	17.8	2.10	7.5	0.94	3.4	0.80	1.6	0.23
Overall	14.6	0.98	6.7	0.45	3.1	0.40	1.2	0.11

Table 18. Summaries of black bear hair trapping on the Okefenokee and Osceola study areas, Georgia and Florida, 1999.

Okefenokee Study Area

Trapline	Number of Trap Sites	Number of Trap Sessions[a]	Number of Bear Visits	Number of Bear Captures	Capture Rate[b] (%)	Trap Sessions per Capture
Big Swamp	23	230	111	93	83.8	2.5
Ok. Sportsman	27	270	148	123	83.1	2.2
Jamestown	24	240	75	69	92.0	3.8
Craven's Island	14	140	101	89	88.1	1.6
Total	88	880	435	374	86.0	2.4

Osceola Study Area

Trapline	Number of Trap Sites	Number of Trap Sessions[a]	Number of Bear Visits	Number of Bear Captures	Capture Rate[b] (%)	Trap Sessions per Capture
Banker's Trust	40	440	354	295	0.83	1.5
Bear Bay	34	374	233	205	0.88	1.8
Low Road	20	220	155	137	0.88	1.6
Total	94	1,034	742	637	0.86	1.6

[a] = Number of trap sessions refers to the number of hair traps times the number of periods the hair traps were activated.
[b] = % rate of capture equals the number of bear captures divided by the number of bear visits.

Table 19. Observed alleles and frequencies for 39 black bears identified from barbed-wire hair traps for the Okefenokee study area, Georgia, 1999.

Locus	Allele	*n*	Frequency	Locus	Allele	*n*	Frequency
G10C	106[a]	0	0.000	G10X	140	6	0.077
	110	1	0.013		142	5	0.064
	112	3	0.038		144	26	0.333
	114	29	0.372		152	8	0.103
	116	42	0.538		154	26	0.333
	118	3	0.038		156	1	0.013
					160	6	0.077
G1A	183	20	0.256	G10P	148	15	0.192
	187	29	0.372		158[a]	0	0.000
	189	5	0.064		160	4	0.051
	191	9	0.115		162	47	0.603
	193	15	0.192		166	7	0.09
					168	5	0.064
G10B	153	17	0.218	G10L	133	2	0.026
	155	9	0.115		135	1	0.013
	157	10	0.128		137	29	0.372
	159	5	0.064		143	1	0.013
	161	30	0.385		149	12	0.154
	165	5	0.064		151	8	0.103
	167	2	0.026		153	22	0.282
					155	3	0.038
					165[a]	0	0.000
G10M	207	7	0.09	G1D	176	38	0.487
	211	4	0.051		178	5	0.064
	213	23	0.295		180[a]	0	0.000
	215	26	0.333		184	15	0.192
	217	5	0.064		186	10	0.128
	219	13	0.167		188	8	0.103
					190	2	0.026

[a] Indicates alleles that were observed in bears from the Osceola (Florida) study area

Table 20. Observed alleles and frequencies for 37 black bears identified from barbed-wire hair traps for the Osceola study area, Florida, 1999.

Locus	Allele	*n*	Frequency	Locus	Allele	*n*	Frequency
G10C	106	1	0.014	G10X	140[a]	0	0.000
	110[a]	0	0.000		142[a]	0	0.000
	112	2	0.027		144	38	0.514
	114	37	0.500		152	4	0.054
	116	32	0.432		154	26	0.351
	118	2	0.027		156	4	0.054
					160	2	0.027
G1A	183	5	0.068	G10P	148	11	0.149
	187	31	0.419		158	1	0.014
	189	4	0.054		160	5	0.068
	191	20	0.270		162	57	0.770
	193	14	0.189		166[a]	0	0.000
					168[a]	0	0.000
G10B	153	4	0.054	G10L	133	11	0.149
	155	12	0.162		135[a]	0	0.000
	157	25	0.338		137	10	0.135
	159	1	0.014		143	2	0.027
	161	27	0.365		149	12	0.162
	165	3	0.041		151	6	0.081
	167	2	0.027		153	22	0.297
					155	5	0.068
					165	6	0.081
G10M	207	13	0.176	G1D	176	32	0.432
	211	4	0.054		178	5	0.068
	213	14	0.189		180	1	0.014
	215	28	0.378		184	8	0.108
	217	2	0.027		186	6	0.081
	219	13	0.176		188	22	0.297
					190[a]	0	0.000

[a] Indicates alleles that were observed in bears from the Okefenokee (Georgia) study area

Table 21. Probability of identity estimates based on 39 individual black bears identified from barbed-wire hair traps on the Okefenokee study area, Georgia, 1999.

Locus	Number of Alleles	Probability of Identity	Probability of Identity (siblings)
G10C	5	0.269	0.533
G1A	5	0.109	0.406
G10B	7	0.085	0.388
G10M	6	0.095	0.394
G10X	7	0.099	0.399
G10P	5	0.211	0.510
G10L	8	0.103	0.403
G1D	6	0.129	0.435
Overall	6.13[a]	6.57×10^{-8} [b]	1.00×10^{-3} [b]

[a] Average number of alleles
[b] Product of individual values

Table 22. Probability of identity estimates based on 37 individual black bears identified from barbed-wire hair traps on the Osceola study area, Florida, 1999.

Locus	Number of Alleles	Probability of Identity	Probability of Identity (siblings)
G10C	5	0.287	0.541
G1A	5	0.133	0.429
G10B	7	0.124	0.421
G10M	6	0.096	0.396
G10X	5	0.225	0.503
G10P	4	0.417	0.664
G10L	8	0.051	0.349
G1D	6	0.135	0.433
Overall	5.75[a]	2.92×10^{-7} [b]	2.00×10^{-3} [b]

[a] Average number of alleles
[b] Product of individual values

Table 23. Observed capture frequencies of bears identified at hair traps on the Okefenokee study area and the zero-truncated Poisson frequencies to be expected if catchability is constant (1999).

Number of times captured (i)	Number of individuals (f)		Expected frequencies E(f)		$\frac{[f - \mathrm{E}(f)]^2}{\mathrm{E}(f)}$
1	27		15.785		7.967
2	5		12.628		4.608
3	3	7	6.735	10.586[a]	1.215
4	1		2.694		
5	2		0.862		
6	0		0.230		
7	0		0.053		
8	0		0.011		
9	0		0.002		
10	0		0.000		
11	0		0.000		
12	0		0.000		
13	0		0.000		
14	0		0.000		
15	0		0.000		
16	0		0.000		
17	0		0.000		
18	1		0.000		
	39		39.000		$\chi^2 = 13.790$
					df = 1
					P = 0.0002

[a] Capture frequencies ≥3 were pooled so that expected frequencies would be ≥5 (Caughley 1977).

Table 24. Estimated black bear population size from hair captures using multiple mark-recapture models in the Okefenokee study area, Georgia, 1999.

Model	Population Size Estimate	Coefficient of Variation (%)	95% Confidence Interval	Density (bears/km^2)	95% Confidence Interval
M_o	84	26	57–151	0.16	0.11–0.30
M_h[a]	71	11	59–91	0.14	0.12–0.18
M_t	84	26	55–148	0.16	0.11–0.29
M_b	117	118	47–849	0.23	0.09–1.66
M_{bh}	117	119	47–851	0.23	0.09–1.67
M_{tb}[b]	---	---	---	---	---
Chao M_h	175	48	84–452	0.34	0.16–0.88
Chao M_t	110	38	64–243	0.22	0.13–0.48
Chao M_{th}	292	88	88–1,357	0.57	0.17–2.66

[a] Indicates selected model
[b] Population size estimate and associated standard errors were impossibly large

Table 25. Observed capture frequencies of bears identified at hair traps on the Osceola study area and the zero-truncated Poisson frequencies to be expected if catchability is constant (1999).

Number of times captured (i)	Number of individuals (f)		Expected frequencies E(f)		$\frac{[f - E(f)]^2}{E(f)}$
1	14		11.999		0.334
2	13		11.675		0.150
3	5		7.573		0.874
4	3		3.684		
5	0		1.434		
6	1		0.465		
7	0	5	0.129	5.753[a]	0.098
8	0		0.031		
9	0		0.007		
10	0		0.001		
11	1		0.000		
	37		37.000		$\chi^2 = 1.457$
					df = 2
					P = 0.483

[a] Capture frequencies ≥4 were pooled so that expected frequencies would be ≥5 (Caughley 1977).

Table 26. Estimated black bear population size from hair captures using multiple mark-recapture models in the Osceola study area, Florida, 1999.

Model	Population Size Estimate	Coefficient of Variation (%)	95% Confidence Interval	Density (bears/km^2)	95% Confidence Interval
M_o[c]	44	9	40–57	0.12	0.11–0.16
M_h	50	12	43–66	0.14	0.12–0.18
M_t	44	9	40–56	0.12	0.11–0.15
M_b	48	21	40–87	0.13	0.11–0.24
M_{bh}	48	21	40–87	0.13	0.11–0.24
M_{tb}	47	35	39–130	0.13	0.11–0.36
Chao M_h	48	15	41–71	0.13	0.11–0.19
Chao M_t	45	12	40–63	0.12	0.11–0.17
Chao M_{th}	47	16	40–73	0.13	0.11–0.20

[a] Two sampling sessions of 5 and 6 periods each
[b] Two sampling sessions of 6 and 5 periods each
[c] Indicates selected model

Table. 27. Observed capture frequencies of bears identified at snares and hair traps on the Okefenokee study area and the zero-truncated Poisson frequencies to be expected if catchability is constant (1995–1999).

Number of times captured (i)	Number of individuals (f)		Expected frequencies E(f)		$\frac{[f - E(f)]^2}{E(f)}$
1	82		61.991		6.458
2	28		46.184		7.159
3	16		22.938		
4	9		8.544		
5	7		2.546		
6	0		0.632		
7	0		0.135		
8	0		0.025		
9	0		0.004		
10	0	17	0.001	11.887[a]	2.119
11	0		0.000		
12	0		0.000		
13	0		0.000		
14	0		0.000		
15	0		0.000		
16	0		0.000		
17	0		0.000		
18	1		0.000		
	143		143.000		$\chi^2 = 17.915$
					df = 2
					P = 0.000129

[a] Capture frequencies ≥4 were pooled so that expected frequencies would be ≥5 (Caughley 1977).

Table 28. Observed capture frequencies of bears identified at snares and hair traps on the Osceola study area and the zero-truncated Poisson frequencies to be expected if catchability is constant (1999).

Number of times captured (i)	Number of individuals (f)		Expected frequencies E(f)		$\frac{[f - \mathrm{E}(f)]^2}{\mathrm{E}(f)}$
1	35		28.638		1.413
2	32		28.996		0.311
3	11		19.572		3.754
4	7		9.908		0.854
5	2		4.013		
6	2		1.354		
7	2		0.392		
8	0	8	0.099	5.886[a]	0.759
9	1		0.022		
10	0		0.005		
11	0		0.001		
12	1		0.000		
	93		93.00		χ^2 = 7.092
					df = 3
					P = 0.06902

[a] Capture frequencies ≥5 were pooled so that expected frequencies would be ≥5 (Caughley 1977).

Table 29. Estimated black bear population size from the Jolly-Seber models in Okefenokee (OKE) and Osceola (OSC) study areas using a combination of live-capture and hair-trapping data, Georgia and Florida, 1995–1999.

Study Area	Year	Model A[a,e]		Model A'[b]		Model B[c,f]		Model D[d]	
		$\hat{N}$	(95% CI)	$\hat{N}$	(95% CI)	$\hat{N}$	(95% CI)	$\hat{N}$	(95% CI)
OKE	1995	---	---	304	(209–398)	---	---	---	---
OKE	1996	58	(33–83)	153	(104–201)	79	(53–105)	63	(46–81)
OKE	1997	82	(44–119)	137	(93–181)	84	(57–110)	79	(57–101)
OKE	1998	64	(41–87)	110	(72–148)	64	(48–79)	86	(62–111)
OKE	1999	---	---	---	---	65	(40–89)	81	(55–107)
OKE	Mean	68	(50–85)	176	(144–207)	73	(41–104)	77	(41–113)
OSC	1996	---	---	117	(96–138)	---	---	---	---
OSC	1997	102	(54–149)	128	(92–164)	95	(64–125)	98	(66–131)
OSC	1998	77	(44–111)	95	(63–127)	92	(58–127)	89	(59–119)
OSC	1999	---	---	---	---	99	(51–147)	91	(55–127)
OSC	Mean	90	(61–119)	114	(96–131)	95	(38–153)	93	(43–143)

Table 30. Overall denning chronology of radiocollared black bears on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1998.

Okefenokee study area								
		Entry date		Emergence date		Denning period		
Sex/status	*n*	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	Range
Female								
Pregnant	35	10 Dec	1.1	26 Mar	4.1	105.6	4.3	67–169
With yearling	15	4 Jan	7.8	2 Apr	6.4	88.9	7.4	31–136
Solitary	14	5 Jan	3.6	22 Mar	5.8	77.0	6.0	42–129
Male	9	31 Dec	5.9	12 Mar	6.0	71.6	8.8	34–107

Osceola study area								
		Entry date		Emergence date		Denning period		
Sex/status	*n*	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	Range
Female								
Pregnant	22	10 Dec	1.8	30 Mar	4.9	110.0	5.4	78–148
With yearling	8	2 Jan	4.6	15 Mar	4.4	72.0	5.8	47–95
Solitary	5	30 Dec	9.6	15 Mar	6.0	75.4	5.9	55–90

Table 31. Annual denning chronology of radiocollared female black bears on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1998.

Site/year	n	Entry date $\bar{x}$	Entry date SE	Emergence date $\bar{x}$	Emergence date SE	Denning period $\bar{x}$	Denning period SE	Denning period Range
Okefenokee								
1995	17	9 Jan	4.3	2 Apr	6.9	83.7	6.6	48–159
1996	21	11 Dec	1.0	3 Apr	4.8	112.3	5.2	72–137
1997	17	21 Dec	6.7	28 Mar	4.4	96.2	8.3	31–143
1998	15	9 Dec	2.0	13 Mar	4.4	93.8	5.1	67–154
Osceola								
1996	9	12 Dec	1.8	1 Apr	7.1	109.3	6.7	82–138
1997	15	24 Dec	5.6	1 Apr	5.4	98.5	9.5	47–148
1998	15	13 Dec	2.4	7 Mar	1.5	83.7	2.6	65–103

Table 32. Summary of habitat types used for denning by female black bears on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1998.

Study area, year	Habitat type					Sum
	Blackgum	Cypress	Pine	Shrub	Shrub/mix	
Georgia						
1995	10	5	0	5	0	20
1996	4	4	1	4	9	22
1997	5	1	0	9	9	24
1998	4	3	0	6	3	16
Total	23	13	1	24	21	82
Proportion	0.28	0.16	0.01	0.29	0.26	
Florida						
1996	0	0	1	8	0	9
1997	0	0	0	14	0	14
1998	0	0	0	15	0	15
Total	0	0	1	38	0	39
Proportion	0.00	0.00	0.03	0.97	0.00	

Table 33. Mean litter sizes for female bears on the Okefenokee and Osceola study areas, Georgia and Florida, 1996–1999.

Study area,	Number of		Litter size		
year	litters	cubs	$\bar{x}$	SE	Range
Georgia					
1996	1	3	3.0	---	---
1997	19	39	2.1	0.52	1–3
1998	0	0	---	---	---
1999	14	30	2.1	0.77	1–4
	34	70	2.1	0.64	1–4
Florida					
1997	8	15	1.9	0.83	1–3
1998	5	11	2.2	0.84	1–3
1999	9	20	2.2	0.44	2–3
	22	46	2.1	0.68	1–3

Table 34. Black bear population parameter estimates used for population simulations, Okefenokee study area, 1999.

Parameter	$\bar{x}$	SE
Cub-of-the-year (COY) survival	0.750	0.075
Litter COY survival	0.941	0.070
Subadult (1–3) survival (male)	0.750	0.177
Subadult (1–3) survival (female)	0.960	0.049
Adult (4+) survival (male)	0.980	0.042
Adult (4+) survival (female)	0.950	0.036
Litter production rate (age 3)	0.100	0.030
Litter production rate (age 4–8)	0.500	0.289
Litter production rate (age 9–14)	0.625	0.239
Probability of COY litter = 1 (age 3–8)	0.173	---
Probability of COY litter = 2 (age 3–8)	0.655	---
Probability of COY litter = 3 (age 3–8)	0.138	---
Probability of COY litter = 4 (age 3–8)	0.034	---
Probability of COY litter = 1 (age 9–14)	0.050	---
Probability of COY litter = 2 (age 9–14)	0.525	---
Probability of COY litter = 3 (age 9–14)	0.375	---
Probability of COY litter = 4 (age 9–14)	0.005	---

Table 35. Black bear population parameter estimates used for population simulations, Osceola study area, 1999.

Parameter	$\bar{x}$	SE
Cub-of-the-year (COY) survival	0.950	0.053
Litter COY survival	0.950	0.053
Subadult (1–3) survival (male)	0.800	0.240
Subadult (1–3) survival (female)	0.950	0.017
Adult (4+) survival (male)	0.900	0.270
Adult (4+) survival (female)	0.976	0.009
Litter production rate (age 3)	0.667	0.300
Litter production rate (age 4–8)	0.958	0.042
Litter production rate (age 9–14)	0.834	0.136
Probability of COY litter = 1 (age 3)	0.283	
Probability of COY litter = 2 (age 3)	0.617	
Probability of COY litter = 3 (age 3)	0.050	
Probability of COY litter = 4 (age 3)	0.050	
Probability of COY litter = 1 (age 4–8)	0.201	---
Probability of COY litter = 2 (age 4–8)	0.506	---
Probability of COY litter = 3 (age 4–8)	0.243	---
Probability of COY litter = 4 (age 4–8)	0.050	---
Probability of COY litter = 1 (age 9–14)	0.050	---
Probability of COY litter = 2 (age 9–14)	0.283	---
Probability of COY litter = 3 (age 9–14)	0.617	---
Probability of COY litter = 4 (age 9–14)	0.050	---

Table. 36. Frequency of occurrence (%) and volume percent of items identified in 1,457 black bear scats, Okefenokee study area, Georgia, 1995–1999.

	% Frequency of Occurrence (O) and % Volume (V)				
	Spring	Summer	Fall	Winter	Annual
	(*n* = 66)	(*n* = 158)	(*n* = 1,193)	(*n* = 39)	(*n* = 1,457)
Food Item	O[a] / V[b]	O / V	O / V	O / V	O / V
Crops	**9 / 14**	**17 / 24**	**2 / 2**		**4 / 5**
Zea mays	9 / 14	17 / 24	2 / 2		4 / 5
Tree Fruit		**12 / 10**	**55 / 61**	**8 / 8**	**44 / 51**
Nyssa sylvatica		11 / 9	34 / 37		27 / 32
Persea borbonia rb			3 / 3	2 / T	3 / 2
Quercus spp.		T[c] / T	18 / 21	6 / 8	14 / 17
Shrub / Vine Fruit	**38 / 56**	**38 / 51**	**32 / 36**	**24 / 38**	**33 / 39**
Gaylussacia spp.	14 / 23	T / 1			1 / 1
Ilex coriacea		23 / 32	T / T		4 / 4
Ilex glabra	2 / 3	T / T	5 / 5	3 / 5	4 / 5
Phytolacca americana		T / T	T / T		T / T
Serenoa repens (fruit)		3 / 4	25 / 30		19 / 25
Serenoa repens (shoot)	2 / 5	4 / 6	1 / T		2 / 1
Smilax spp.		1 / T	1 / T	21 / 33	2 / 1
Vaccinium spp.	19 / 26	T / T			1 / 1
Vitis spp.		5 / 6	T / T		1 / 1
Animal Matter	**32 / 8**	**20 / 4**	**9 / T**	**35 / 9**	**13 / 1**
Solenopsis spp.	9 / 2	1 / T		16 / 3	1 / T
Roach			T / T		T / T
Polistes spp.		T / T			T / T
Vespula maculifrons	1 / T	T / T	T / T		T / T
Beeswax	1 / 1				T / T
Coleoptera	13 / 1	16 / 1	8 / T	16 / 1	10 / T

Table. 36. (Continued).

	% Frequency of Occurrence (F) and % Volume (V)				
	Spring (*n*=129)	Summer (*n*=X)	Fall (*n*=X)	Winter (*n*=X)	Annual (*n*=1,457)
Food Item	O / V	O / V	O / V	O / V	O / V
Animal (cont.)					
Crawfish	1 / T		T / T		T / T
Reptile eggs	2 / 2	1 / 2	T / T		T / T
Dasypus novemcinctus	1 / T				**T / T**
Odocoileus viginianus	1 / 1		T / T	3 / 5	**T / T**
Sus scrofa	1 / T	T / 1			T / T
Ursus americanus		1 / T			T / T
Unknown	3 / T	1 / T	T / T		1 / T
Vegetation	**8 / 8**	**7 / 9**	**1 / 1**	**15 / 20**	**3 / 2**
Graminae	8 / 8	6 / 8	T / T	2 / 1	2 / 1
Sphagnum spp.				10 / 15	T / T
Unknown	T / T	1 / 1	1 / T	3 / 4	1 / T
Debris	**13 / 14**	**6 / 2**	**1 / T**	**18 / 25**	**3 / 2**
Natural	12 / 14	5 / 2	T / T	18 / 25	3 / 2
Garbage	1 / T	1 / T	T / T		T / T

[a] = Percent frequency of occurrence
[b] = Volume percent
[c] = Trace amount (<1%)

Table. 37. Frequency of occurrence (%) and volume percent of items identified in 703 black bear scats, Osceola study area, Florida, 1996–1999.

	% Frequency of Occurrence (F) and % Volume (V)				
	Spring	Summer	Fall	Winter	Annual
	(*n* = 77)	(*n* = 241)	(*n* = 359)	(*n* = 26)	(*n* = 703)
Food Item	O[a] / V[b]	O / V	O / V	O / V	O / V
Crops	**19 / 22**	**28 / 39**	**34 / 40**	**25 / 28**	**29 / 37**
Corn	19 / 22	28 / 39	34 / 40	23 / 25	29 / 37
Millet				2 / 4	T[c] / T
Tree Fruit		**1 / 1**	**24 / 23**		**12 / 12**
Nyssa sylvatica		1 / T	23 / 22		11 / 11
Persea borbonia rb			1 / 1		T / T
Quercus spp.		T / T			T / T
Magnolia virginiana			T / T		T / T
Shrub / Vine Fruit	**49 / 66**	**46 / 51**	**34 / 36**	**65 / 68**	**42 / 45**
Ilex coriacea		19 / 23	2 / 1		9 / 9
Ilex glabra	6 / 8	T / 1	3 / 2	15 / 13	3 / 3
Rubus spp.	8 / 12				1 / 1
Serenoa repens (fruit)	1 / T	7 / 9	28 / 33	43 / 54	17 / 22
Serenoa repens (shoot)	8 / 11	9 / 8	1 / T	2 / T	5 / 4
Smilax spp.	4 / 3	1 / T	T / T	5 / T	1 / T
Vaccinium spp.	22 / 31	1 / 1			3 / 4
Vitis spp.		7 / 8	T / T		3 / 3
Animal Matter	**15 / 3**	**11 / 2**	**5 / T**	**7 / T**	**9 / 1**
Solenopsis spp. ant	5 / 1	1 / T			1 / T
Vespula maculifrons	1 / T	1 / T	T / T	2 / T	T / T
Coleoptera	6 / T	5 / 1	3 / T	5 / T	4 / T

Table. 37. (Continued).

	% Frequency of Occurrence (F) and % Volume (V)				
	Spring (*n*=77)	Summer (*n*=241)	Fall (*n*=359)	Winter (*n*=26)	Annual (*n*=703)
Food Item	O / V	O / V	O / V	O / V	O / V
Animal (cont.)					
Dragonfly		T / T			T / T
Reptile eggs		T / T			T / T
Odocoileus viginianus	1 / T	1 / T			T / T
Unknown	3 / T	3 / T	1 / T		2 / T
Vegetation	**11 / 6**	**12 / 6**	**2 / T**	**3 / 3**	**7 / 3**
Graminae	5 / 2	3 / 2	T / T	3 / 3	2 / 1
Sphagnum spp.	1 / T				T / T
Unknown	**6 / 3**	**9 / 4**	**1 / T**		**5 / 2**
Debris	6 / 3	1 / 1	1 / T		1 / 1
Natural	6 / 3	1 / 1	T / T		1 / 1
Garbage			T / T		T / T
Unknown	T / T	1 / T	T / T		T / T

[a] = Percent frequency of occurrence
[b] = Volume percent
[c] = Trace amount (<1%)

Table 38. Mean annual home range sizes (km^2) of radiocollared black bears using the 95% fixed kernel estimator, Okefenokee and Osceola study areas, Georgia and Florida, 1996–1999.

Study area,	Female home ranges			Male home ranges		
year	*n*	$\bar{x}$	SE	*n*	$\bar{x}$	SE
Okefenokee						
1996	18	51.8	14.0	1	208.3	---
1997	16	51.8	11.8	4	294.0	101.0
1998	17	46.7	10.3	3	422.4	210.9
1999	18	72.2	17.8	2	388.0	99.6
Overall	69	55.9	6.9	10	342.8	71.5
Osceola						
1996	5	16.5	2.5	---	---	---
1997	9	21.8	3.1	---	---	---
1998	22	33.9	7.4	---	---	---
1999	17	34.3	7.7	---	---	---
Overall	53	30.3	4.0			

Table 39. Mean annual home range sizes (km^2) of adult ($\geq$4 years) and subadult ($\leq$3 years) radiocollared black bears using the 95% fixed kernel estimator, Okefenokee and Osceola study areas, Georgia and Florida, 1996–1999.

Study area,	Female home ranges			Male home ranges		
age class	*n*	$\bar{x}$	SE	*n*	$\bar{x}$	SE
Okefenokee						
Adult	61	54.4	7.6	7	336.7	95.6
Subadult	8	67.3	16.1	3	356.3	111.8
Osceola						
Adult	45	32.9	4.6	---	---	---
Subadult	8	15.6	2.5	---	---	---

Table 40. Mean seasonal home range sizes (km^2) of radiocollared black bears using the 95% fixed kernel estimator, Okefenokee and Osceola study areas, Georgia and Florida, 1995–1999.

Site, season	Female home range size			Male home range size		
	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Okefenokee						
Spring	15	20.9	7.5	---	---	---
Summer	77	43.7	6.6	16	207.1	38.6
Fall	76	33.8	6.5	18	273.8	61.3
Osceola						
Spring	19	17.4	3.5	---	---	---
Summer	59	24.4	1.9	---	---	---
Fall	60	27.2	4.6	---	---	---

Table 41. Abbreviated habitat use rankings using cover types that make up 93.7% of the Osceola study area. WF=Wet Flatwoods, FR=Forest Regeneration, PP=Pine Plantation, WMF=Wetland Mixed Forest.

Movement category	*F*-value	*P*-value	Johnson Rankings: Least preferred … Most preferred	Significant comparisons	Level of significance
Rests	8.94	<0.001	PP<FR<WF<WMF	PP<FR PP<WF PP<WMF FR<WMF	<0.05 <0.05 <0.05 <0.05
Forage	1.74	>0.10	PP<WF<WMF<FR	None	>0.05
Search	2.33	>0.10	PP<WF<WMF<FR	None	>0.05
Travel	1.73	>0.10	PP<WF<WMF<FR	None	>0.05

Table 42. Stand age use rankings on the Osceola study area, Florida, from least to most preferred using Johnson's (1980) method. Pine Plantation age was grouped in five-year increments.

Movement category	*F*-value	*P*-value	Johnson Rankings (Least preferred → Most preferred)	Significant comparisons	Level of significance
Rest	1.00	>0.10	6-10<1-5<11-15<16-20<21+	None	NS
Forage	3.24	>0.10	11-15<1-5<16-20<6-10<21+	None	NS
Search	2.06	>0.10	1-5<6-10<16-20<11-15<21+	None	NS
Travel	17.8	>0.10	16-20<11-15<1-5<21+<6-10	None	NS

Table 43. Summary of cover type residence time and activity for female black bears on the Osceola study area, Florida, 1999.

Cover type[a]	% Available	Probability of staying	Most likely to move into	Residence time (h)	Proportion of active locations
FR	9.5	0.14	PP	34	0.70
PP	43.5	0.30	WMF	253	0.71
WF	12.5	0.24	WMF	28	0.54
WMF	27.5	0.48	WMF	607	0.58

[a] WF=Wet Flatwoods, FR=Forest Regeneration, PP=Pine Plantation, WMF=Wetland Mixed Forest.

Table 44. Summary of stand age residence time and activity for female black bears on the Osceola study area, Florida, 1999. CC = clear cut. Natural = all non-plantation stands.

Stand age group	% Available	Probability of staying	Most likely to move into	Residence time (h)	Proportion of active locations
CC	6.0	0.19	Natural	15.2	0.78
Natural	50.5	0.60	Natural	529.5	0.56
1-5 yr.	10.5	0.20	Natural	32.8	0.62
6-10 yr.	10.8	0.33	Natural	43.2	0.47
11-15 yr.	14.5	0.27	Natural	35.5	0.58
16-20 yr.	5.4	0.18	Natural	11.7	0.67
21-25 yr.	1.9	0.12	Natural	2.1	0.80

Table 45. Ranking matrices for annual habitat use by black bears at the second (placement of home range within the study area) and third (resource use within the home range) levels of habitat selection, Okefenokee study area, Georgia, 1996–1999. A triple sign indicates significant deviation from random at P = 0.05.

Habitat type	Second-order selection: Habitat types							
	Loblolly bay	Gum/bay/ cypress	Pine/oak	Pine	Disturbed	Shrub wetlands	Swamp forest	Rank
Loblolly bay		+++	+++	+++	+++	+++	+++	1
Gum/bay/cypress	---		+++	+++	+++	+++	+++	2
Pine/oak	---	---		+++	+++	+++	+++	3
Pine	---	---	---		+++	+++	+++	4
Disturbed	---	---	---	---		+	+++	5
Shrub wetlands	---	---	---	---	+		+++	6
Swamp forest	---	---	---	---	---	---		7

Habitat type	Third-order selection: Habitat types							
	Loblolly bay	Gum/bay/ cypress	Pine/oak	Pine	Swamp forest	Shrub wetlands	Disturbed	Rank
Loblolly bay		+	+++	+++	+++	+++	+++	1
Gum/bay/cypress	-		+++	+++	+++	+++	+++	2
Pine/oak	---	---		+	+++	+++	+++	3
Pine	---	---	-		+++	+++	+++	4
Swamp forest	---	---	---	---		+++	+++	5
Shrub wetlands	---	---	---	---	---		+	6
Disturbed	---	---	---	---	---	-		7

Table 46. Ranking matrices for annual habitat use by black bears at the second (placement of home range within the study area) and third (resource use within the home range) levels of habitat selection, Osceola study area, Florida, 1996–1999. A triple sign indicates significant deviation from random at $P = 0.05$.

	Second-order selection: Habitat types							
Habitat type	Gum/bay/ cypress	Pine	Swamp forest	Loblolly bay	Pine/oak	Disturbed	Shrub wetlands	Rank
Gum/bay/cypress		+++	+++	+++	+++	+++	+++	1
Pine	---		+	+++	+++	+++	+++	2
Swamp forest	---	-		+++	+++	+++	+++	3
Loblolly bay	---	---	---		+	+++	+++	4
Pine/oak	---	---	---	-		+++	+++	5
Disturbed	---	---	---	---	---		+	6
Shrub wetlands	---	---	---	---	---	-		7

	Third-order selection: Habitat types							
Habitat type	Gum/bay/ cypress	Swamp forest	Loblolly bay	Shrub wetlands	Pine	Pine/oak	Disturbed	Rank
Gum/bay/cypress		+	+++	+++	+++	+++	+++	1
Swamp forest	-		+++	+++	+++	+++	+++	2
Loblolly bay	---	---		+	+++	+++	+++	3
Shrub wetlands	---	---	-		+	+++	+++	4
Pine	---	---	---	-		+++	+++	5
Pine/oak	---	---	---	---	---		+	6
Disturbed	---	---	---	---	---	-		7

Table 47. Captured nuisance bears and their fates on the Okefenokee study area, Georgia, 1996–1998.

ID	Date captured	Mass (kg)	Sex	Age	Fate
090	12 April 1997	102	M	3	Relocated and established new home range; no additional nuisance activity
103	26 May 1997	66	M	2	Released on site; remained in area with no additional nuisance activity
084	01 June 1997	57	M	2	Released on site; remained in area with no additional nuisance activity
085	13 June 1997	66	M	2	Released on site with continued nuisance activity; euthanized in 1998
999	04 December 1997	75	F	3	Released on site with continued nuisance activity; harvested in 1998
140	24 July 1998	80	F	2	Released on site; remained in area with no additional nuisance activity

Table. 48. Comparison of mean ($\overline{x}$) and maximum (Max) adult ($\geq$3 years) black bear body weights (kg) reported from southeastern coastal plain studies.

		Females			Males		
Locality[a]	Reference	$\overline{x}$	Max	*n*	$\overline{x}$	Max	*n*
ONWR	This study	55.0	102.3	53	110.7	181.8	53
ONF	This study	63.9	97.7	24	133.5	181.8	26
Deltic	Weaver 1999	72.1	88.5	7	144.3	181.4	5
Deltic	Beausoleil 1999	57.5	67.2	4	---	136.2	1
TRNWR	Weaver 1999	74.3	128.8	7	129.9	145.1	5
LARB	Pace et al. 1993	70.0	93.0	13	106.9	128.4	5
MCLB	Brandenburg 1996	63.3	88.5	11	169.3	181.8	2
EAFB	Stratman 1998	53.4	63.6	4	82.2	200.0	17

[a] Locality abbreviations: ONWR = Okefenokee National Wildlife Refuge, Georgia; ONF = Osceola National Forest, Florida; Deltic = Deltic, Tensas River Basin, Louisiana; TRNWR = Tensas River National Wildlife Refuge, Louisiana; LARB = Lower Atchafalaya River Basin, Louisiana; MCLB = Camp Lejeune Marine Corps Base, North Carolina; EAFB = Eglin Air Force Base, Florida.

Table 49. Female survival rates from selected southeastern black bear populations (modified from Martorello 1998).

Locality	Female survival	Reference
Okefenokee Swamp, Georgia	0.87	This study
Osceola National Forest, Florida	0.97	This study
White River NWR, Arkansas	0.95	Smith 1985
White Rock, Arkansas	1.00	Clark 1991
Dry Creek, Arkansas	0.95	Clark 1991
Big Pocosin, North Carolina	1.00	Martorello 1998
Gum Swamp, North Carolina	0.83	Martorello 1998
Camp Lejeune, North Carolina	0.71	Brandenburg 1996
Great Dismal Swamp, North Carolina-Virginia	0.84	Hellgren and Vaughan 1989*b*

Table 50. Population densities of black bears in the southeastern United States.

Locality	Bears / km^2	Reference
Okefenokee Swamp, Georgia	0.14	This study
Osceola National Forest, Florida	0.12	This study
White River NWR, Arkansas	0.29	Smith 1985
White Rock, Arkansas	0.08	Clark 1991
Dry Creek, Arkansas	0.09	Clark 1991
Deltic, Tensas River Basin, Louisiana	1.43	Beausoleil 1999
Tensas River NWR, Louisiana	0.35	Boersen 2001
Alligator River NWR, North Carolina	0.86	Allen 1999
Big Pocosin, North Carolina	0.53	Martorello 1998
Gum Swamp, North Carolina	1.35	Martorello 1998
Camp Lejeune, North Carolina	0.02	Brandenburg 1996
Great Dismal Swamp, North Carolina-Virginia	0.47–0.68	Hellgren and Vaughan 1989*b*
Great Smoky Mountains NP, Tennessee	0.87	J. Chadwick, University of Tennessee, unpublished report

Table 51. Mean dates of den entry, den emergence, and duration of denning period for female black bear populations in the southeastern US.

Location, status	*n*	Entry	Exit	Duration (days)
Pregnant females				
Okefenokee (This study)	35	10 Dec	26 Mar	106
Osceola (This study)	22	10 Dec	30 Mar	110
Tensas River Basin, LA[a]	8	3 Dec	24 Apr	142
White River NWR, AR[b]	6	1 Jan	28 Apr	118
Great Dismal Swamp, VA/NC[c]	6	15 Dec	14 Apr	119
Females with yearlings				
Okefenokee (This study)	15	4 Jan	2 Apr	89
Osceola (This study)	8	2 Jan	15 Mar	72
Tensas River Basin, LA	5	12 Jan	4 Apr	85
White River NWR, AR	2	5 Feb	21 Apr	75
Great Dismal Swamp, VA/NC	4	2 Jan	25 Mar	82
Solitary females				
Okefenokee (This study)	14	5 Jan	22 Mar	77
Osceola (This study)	5	30 Dec	15 Mar	75
Tensas River Basin, LA	1	23 Dec	19 Mar	87
White River NWR, AR	11	7 Jan	16 Apr	98
Great Dismal Swamp, VA/NC	9	2 Jan	21 Mar	74

[a] Weaver 2000; *n* = 9 for for den entry
[b] Oli et al. 1997
[c] Hellgran and Vaughan 1989

Table 52. Estimates of average annual home range size reported for black bears in North America.

Location	Home range area (km^2) Female	Male	Source
Florida	30.3	---	This study[a]
Georgia	55.9	342.8	This study[a]
Alabama	7.8	67.1	Edwards 2002[b]
Louisiana	4.2	7.0	Beausoleil 1999[b]
North Carolina	2.9	12.5	Allen 1999[b]
Florida	88.0	351.0	Stratman 1998[c]
Tennessee	6.9	51.2	van Manen 1994[d]
Arkansas	34.7	89.7	Clark 1991[d]
Virginia	27.0	111.7	Hellgren and Vaughan 1990[d]
Massachusetts	28.0	318.0	Elowe 1984[d]
Alberta	19.6	119.0	Young and Ruff 1982[e]
California	17.1	22.4	Novick and Stewart 1982[d]
Idaho	12.6	60.0	Amstrup and Beecham 1980[d]

[a] 95% fixed kernel method
[b] 95% minimum convex polygon method
[c] 95% adaptive kernel method
[d] 100% minimum convex polygon method
[e] Minimum area method

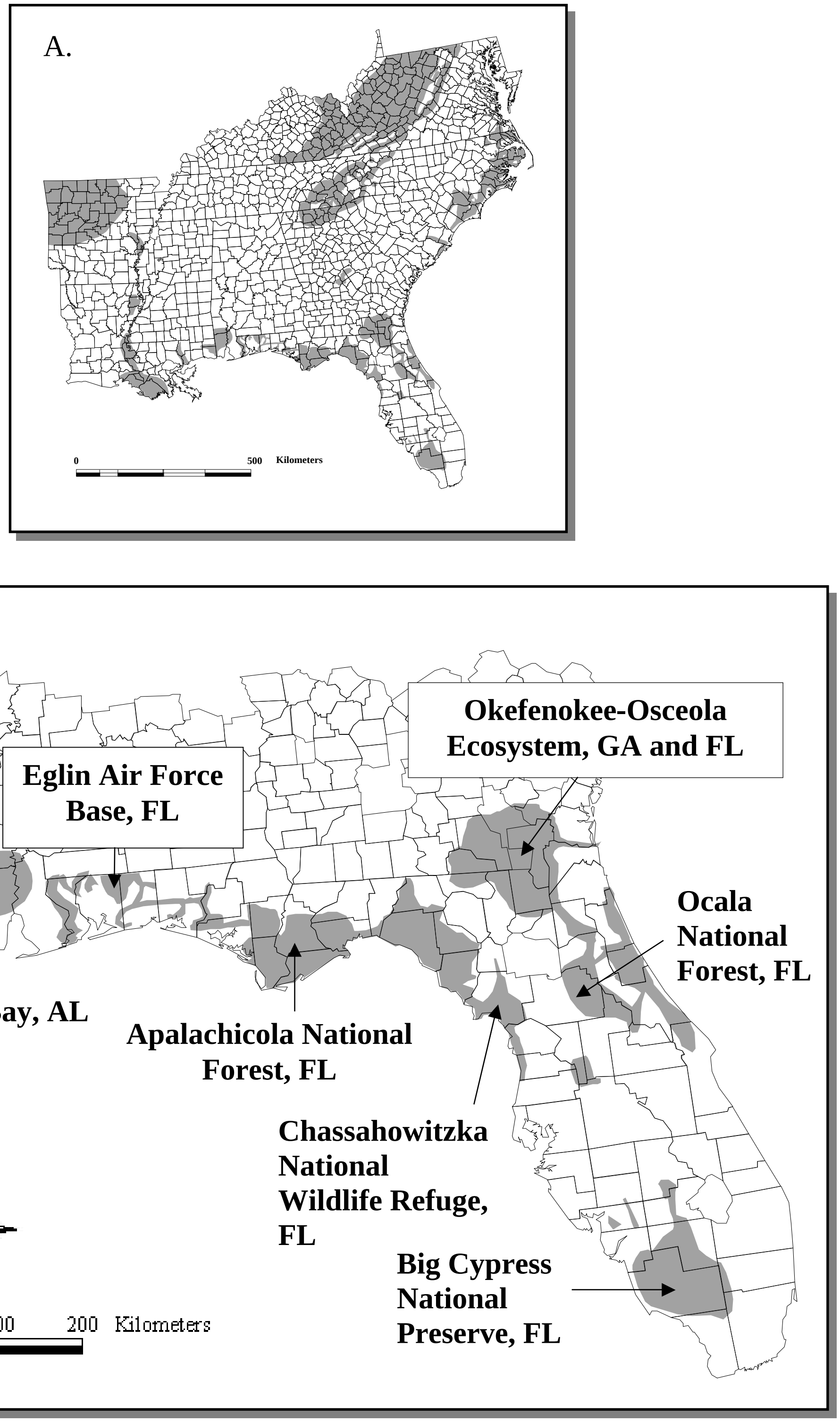

Fig. 1. Current distribution of the American black bear (*Ursus americanus*) in the southeastern United States (from Pelton and van Manen 1997) and (B) current distribution of the 7 relatively disjunct Florida black bear (*U. a. floridanus*) populations.

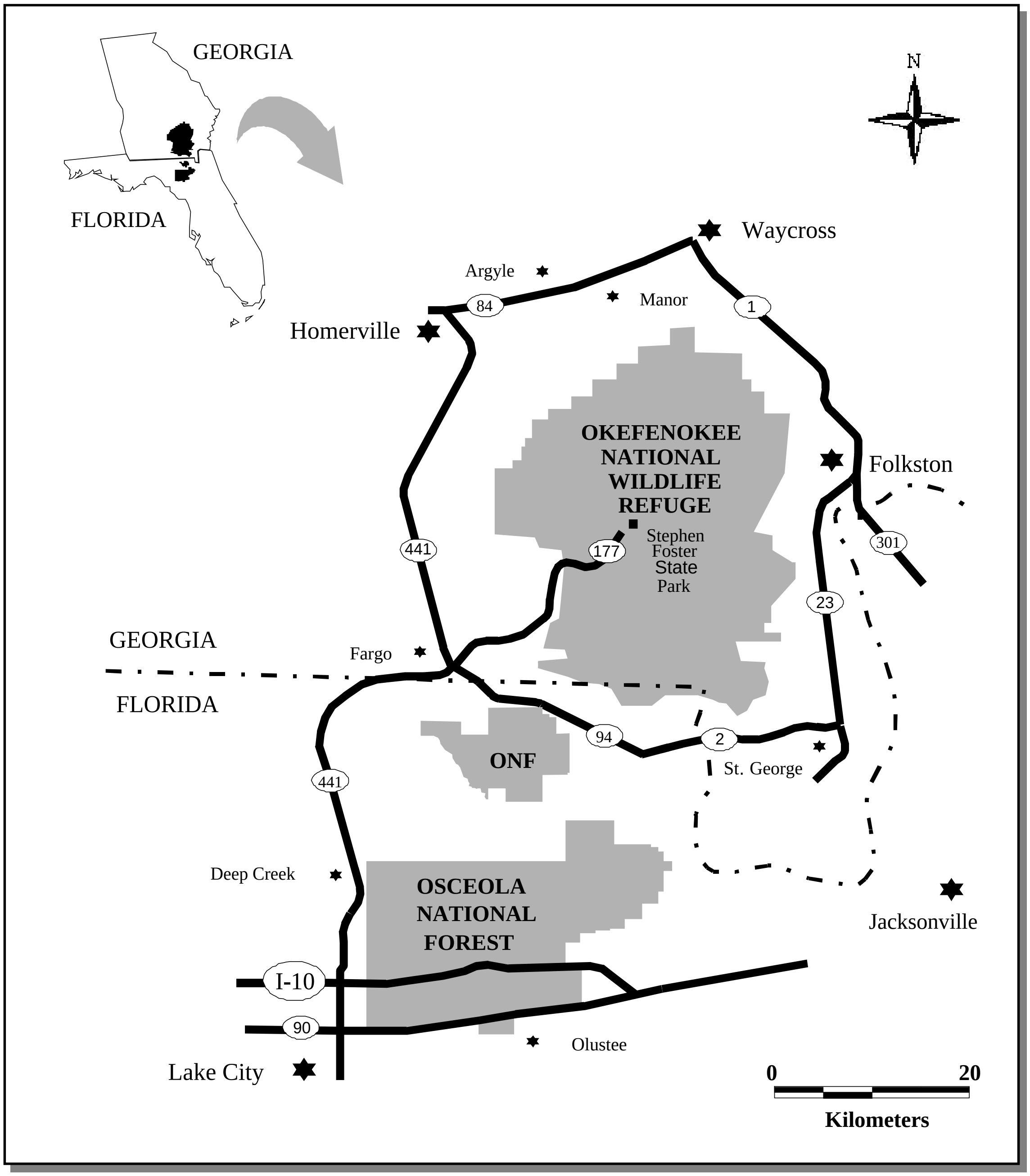

Fig. 2. General area of Okefenokee National Wildlife Refuge, Georgia, and Osceola National Forest, Florida, 1995–1999.

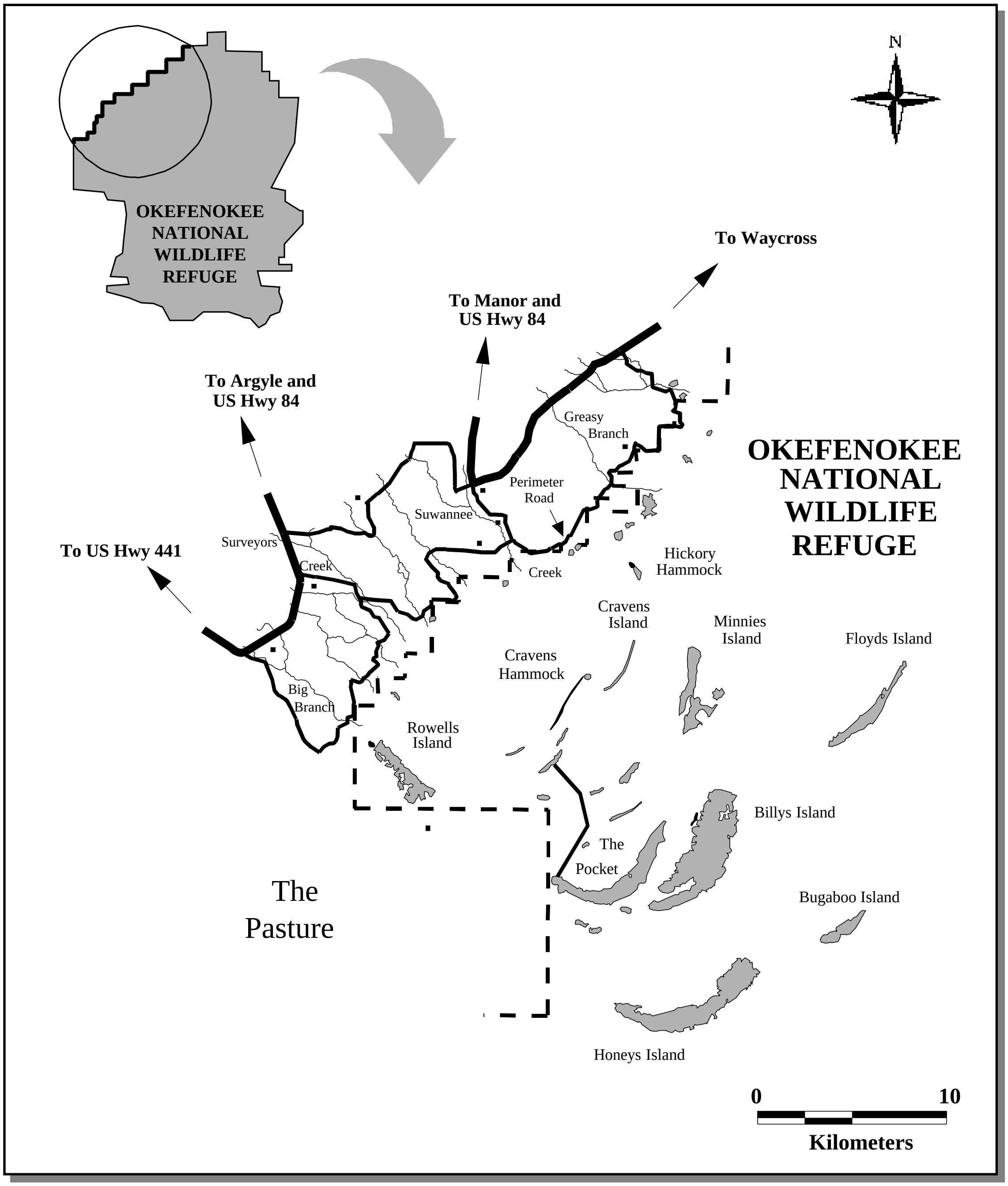

Fig. 3. Okefenokee study area, Georgia, 1995–1999.

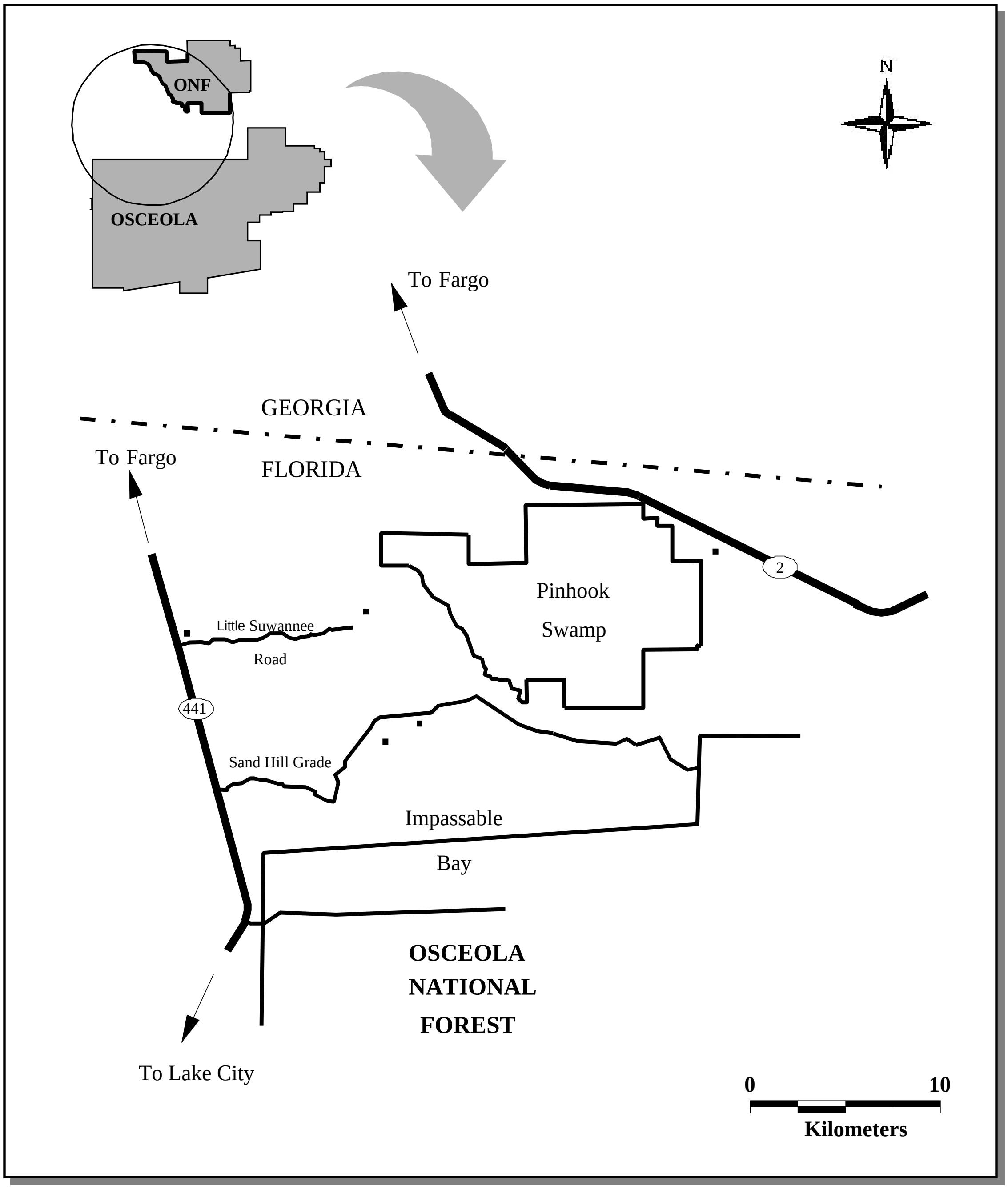

Fig. 4. Osceola study area, Florida, 1996–1999.

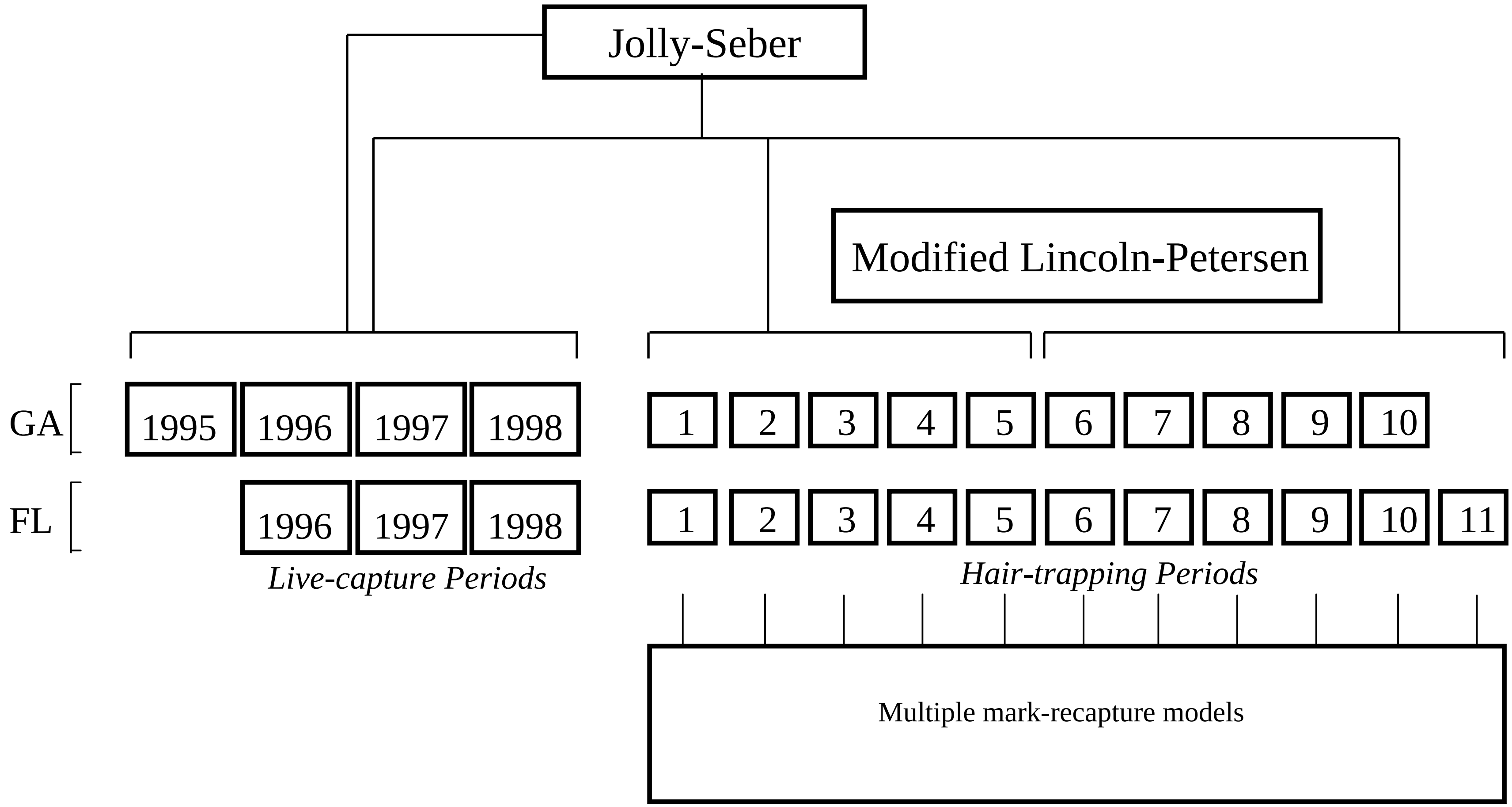

Fig. 5. Capture-recapture models used to estimate black bear population size on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1999.

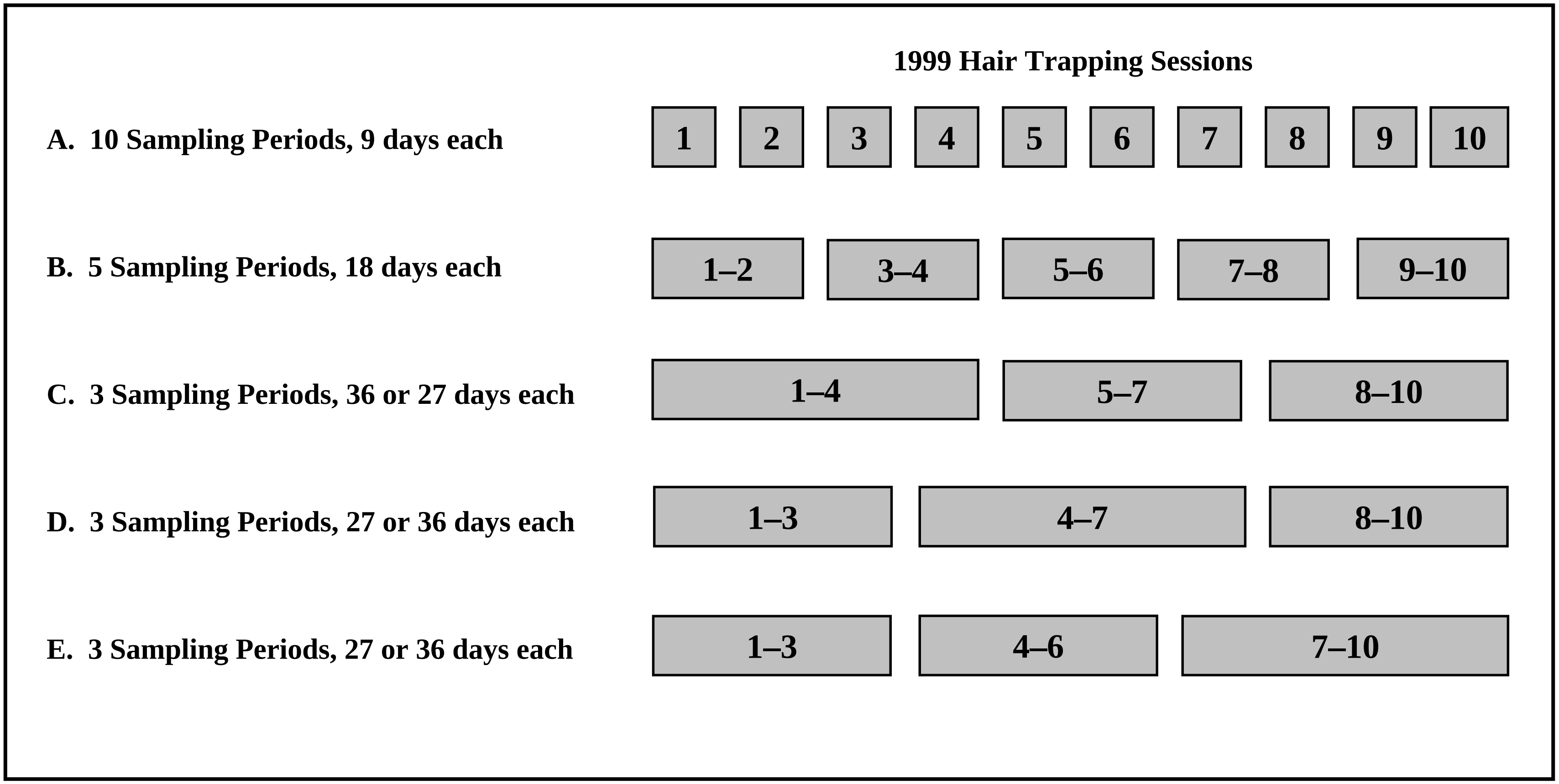

Fig. 6. Pooling configurations of the hair trapping sessions considered for multiple mark-recapture models to estimate population size on the Okefenokee study area, Georgia, 1999.

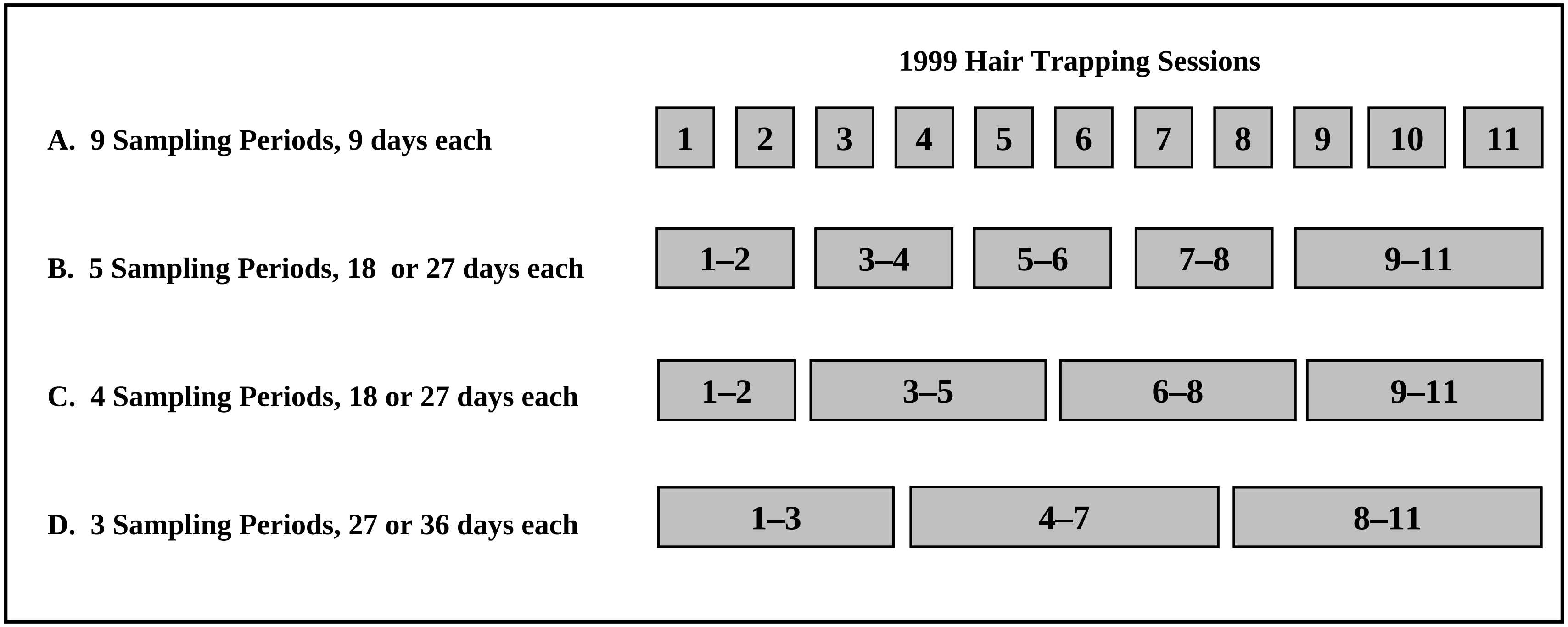

Fig. 7. Pooling configurations of the hair trapping sessions considered for multiple mark-recapture models to estimate population size on the Osceola study area, Florida, 1999.

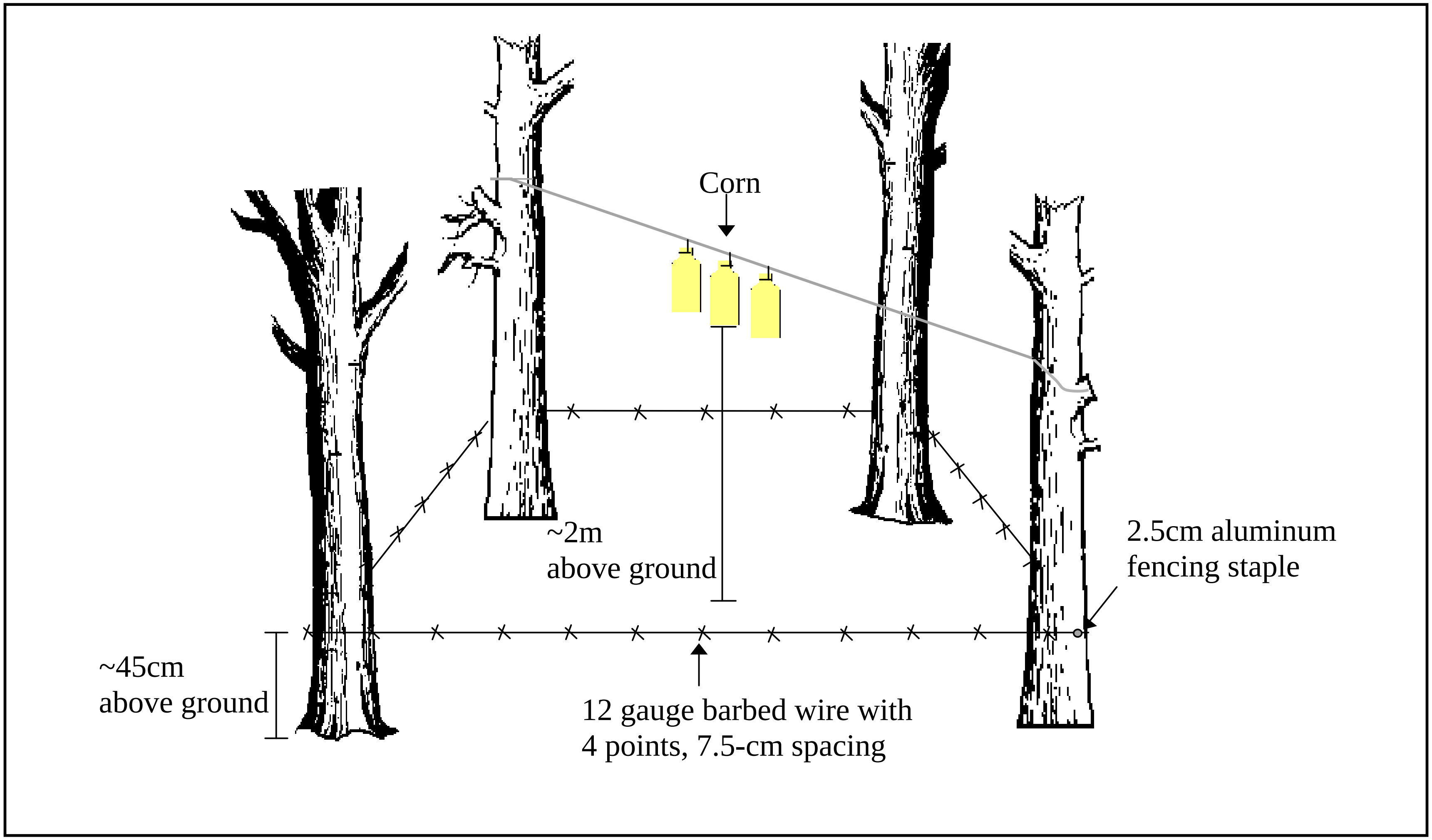

Fig. 8. Diagram of a baited barbed wire enclosure used to collect hair samples from black bears on the Okefenokee and Osceola study areas, Georgia and Florida, 1999.

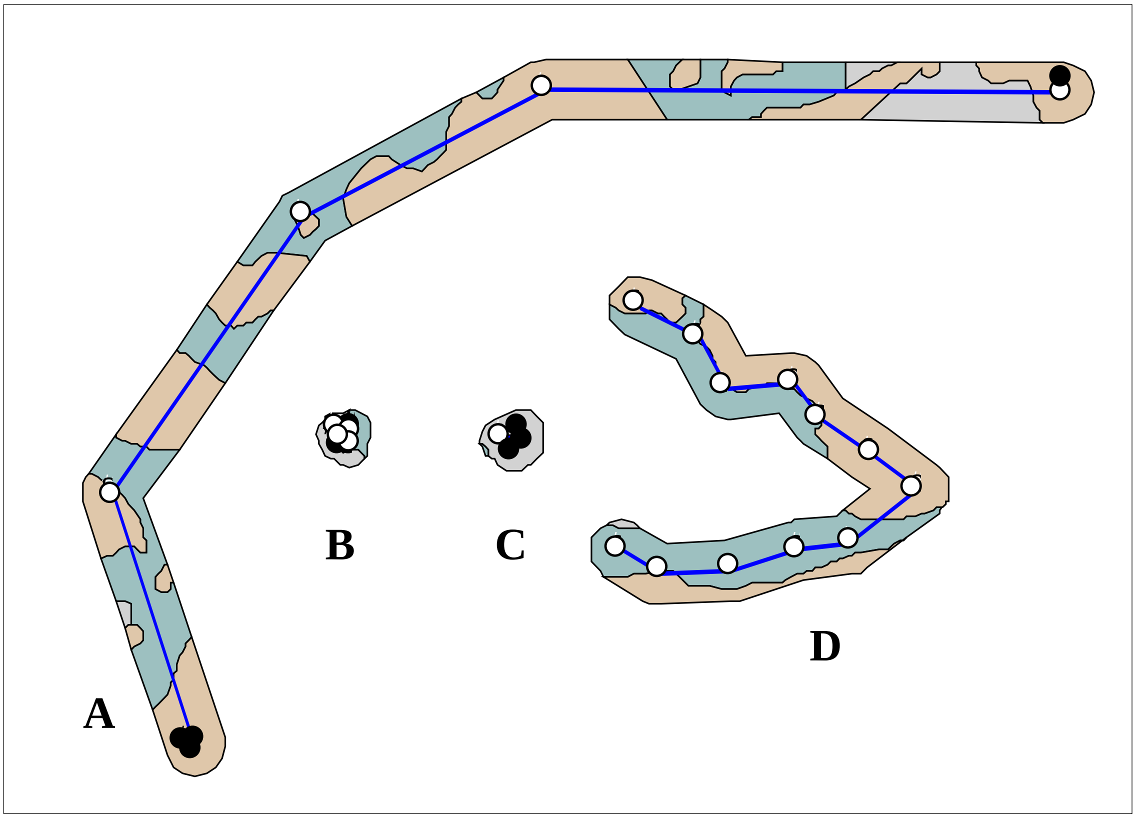

Figure 9. Observed movement patterns of female black bears in north-central Florida. Open circles indicate active bears. Black circles indicate inactive bears. A) Travel path. B) Forage site. C) Rest site. D) Searching.

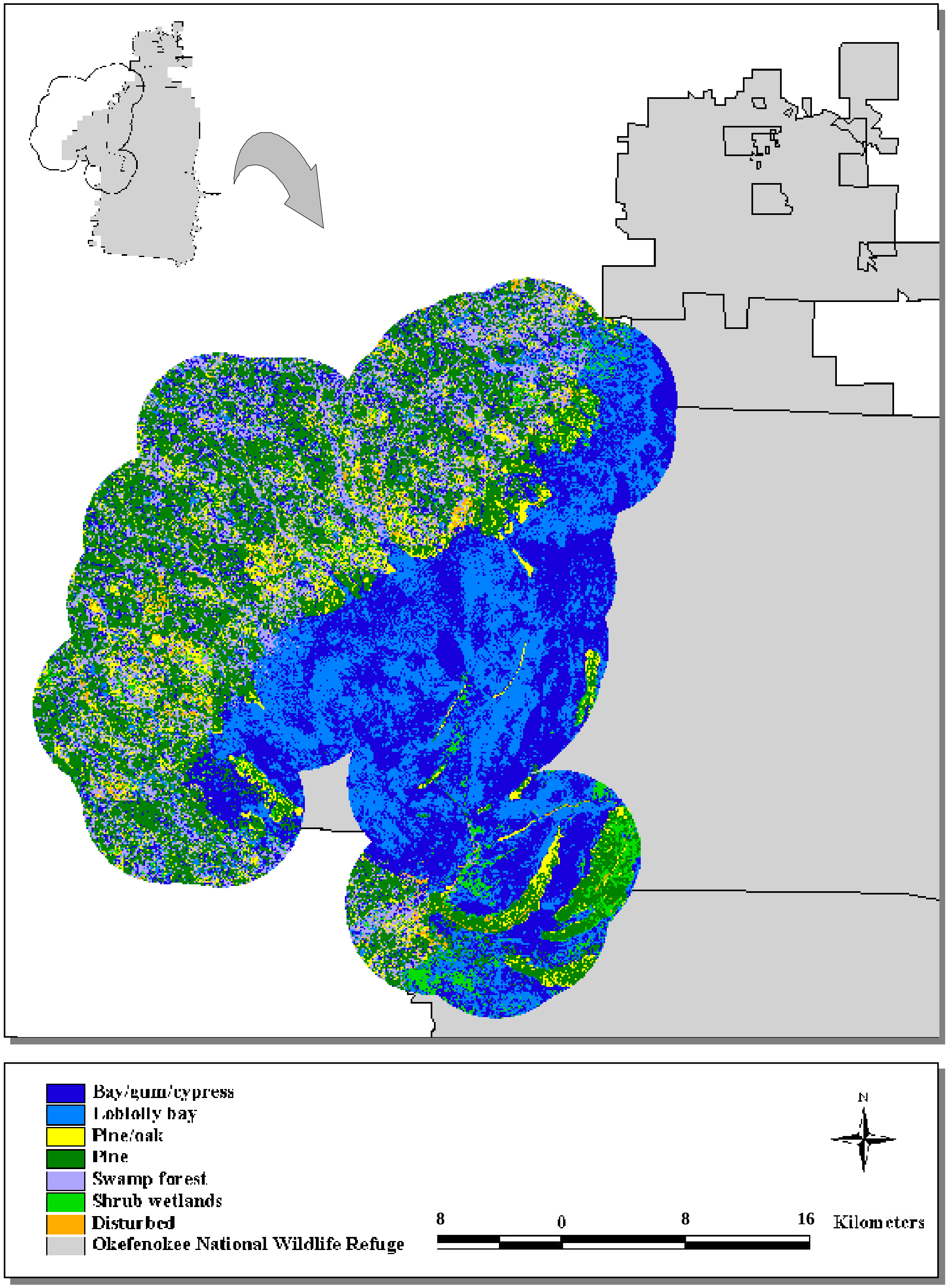

Fig. 10. Composition of habitat types in the Okefenokee study area, Georgia, 1996–1999.

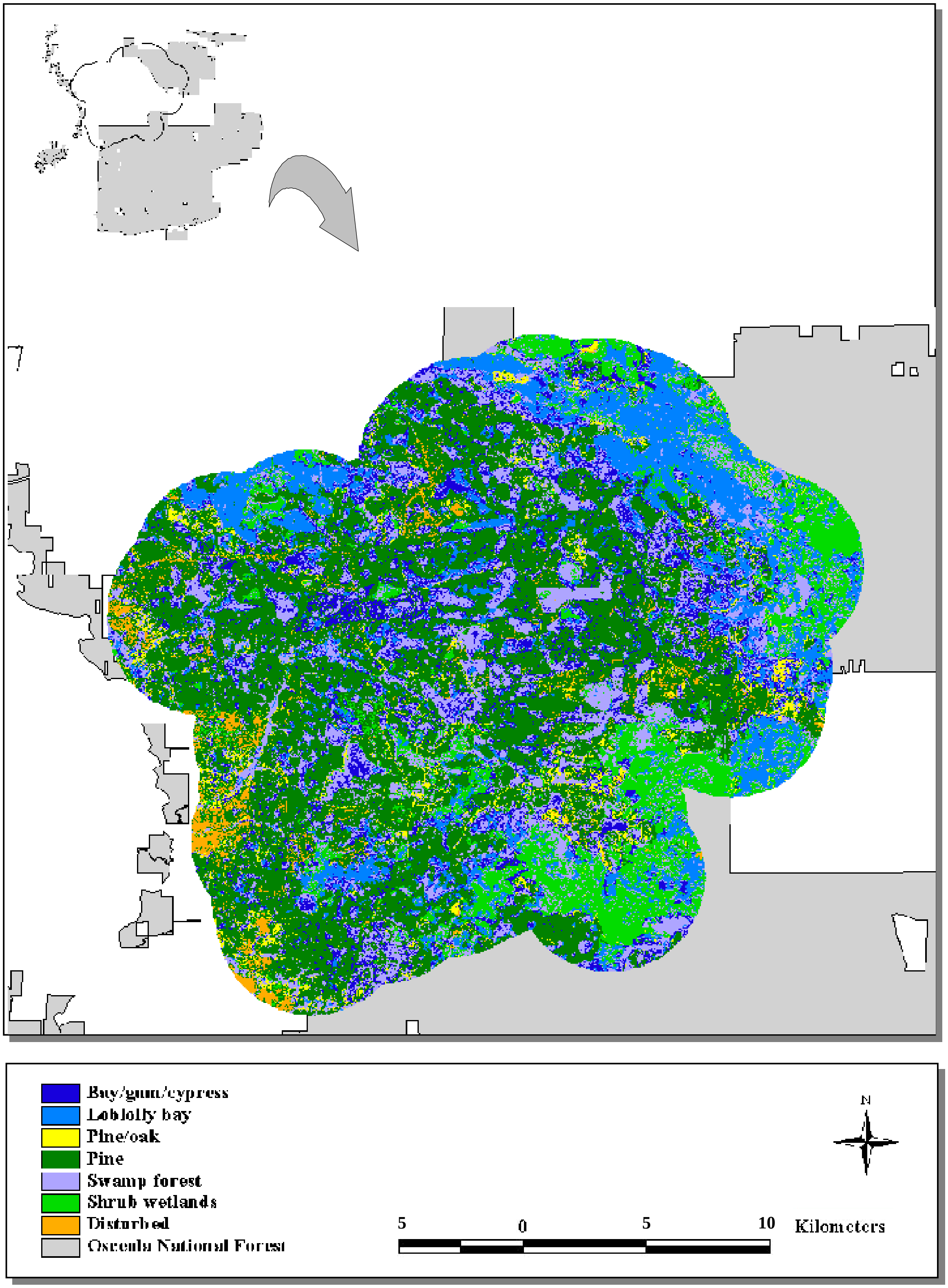

Fig. 11. Composition of habitat types on the Osceola study area, Florida, 1996–1999.

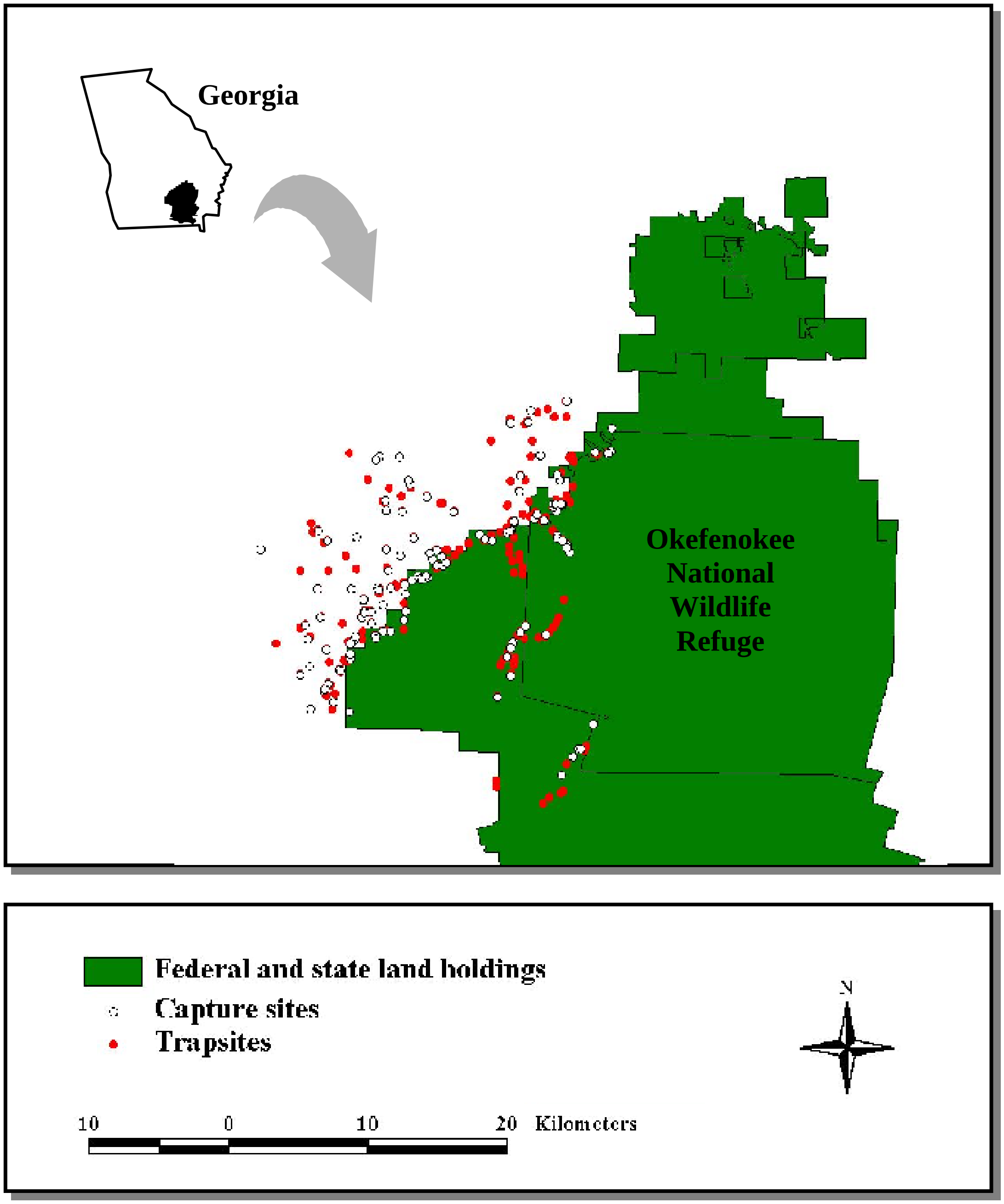

Fig. 12. Locations of snare trapsites on the Okefenokee study area, Georgia, 1995–1998.

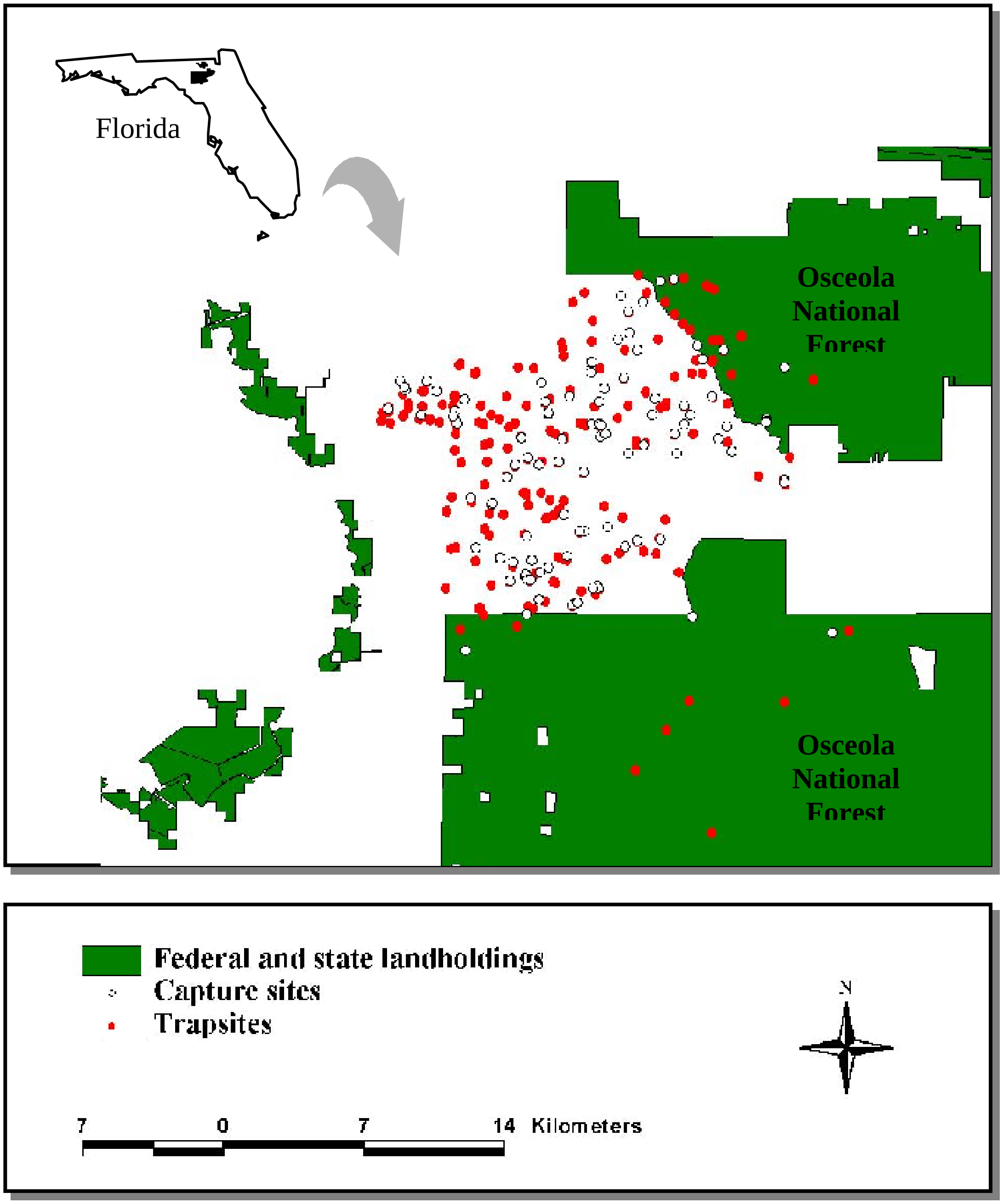

Fig. 13. Locations of snare trapsites on the Osceola study area, Florida, 1996–1999.

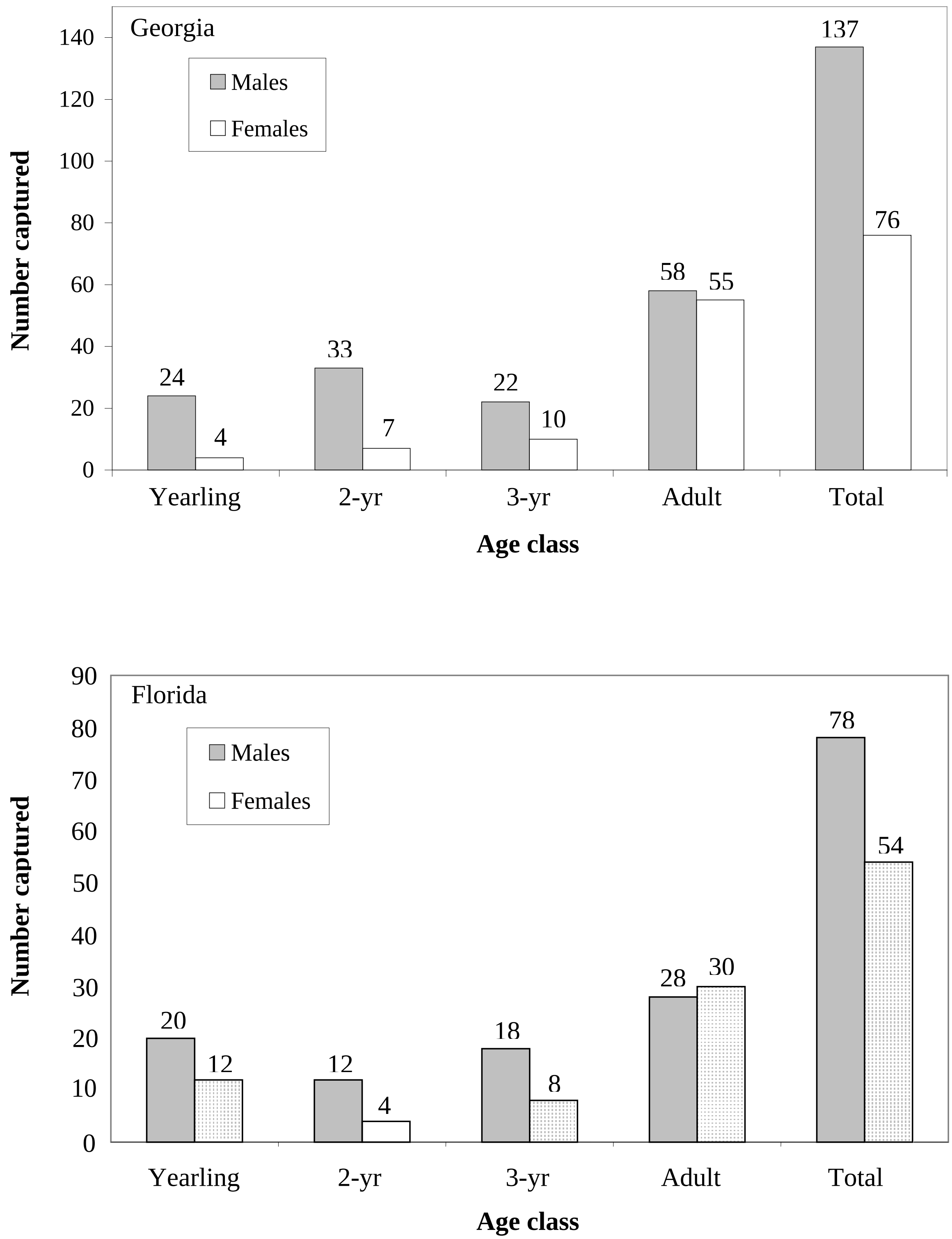

Fig. 14. Sex ratios by age class of black bears captured on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1998.

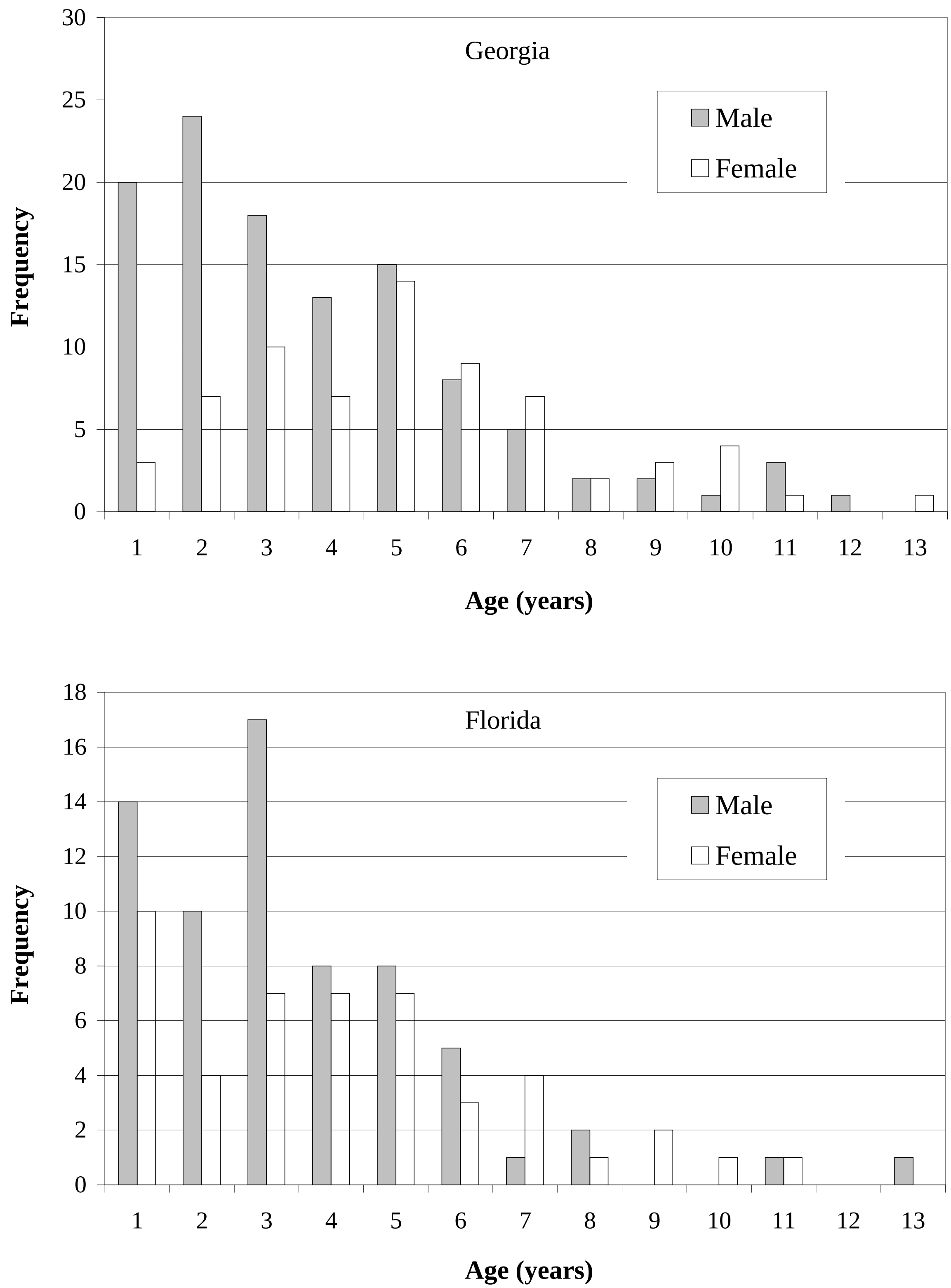

Fig. 15. Ages of black bears captured on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1998. Ages are at time of capture.

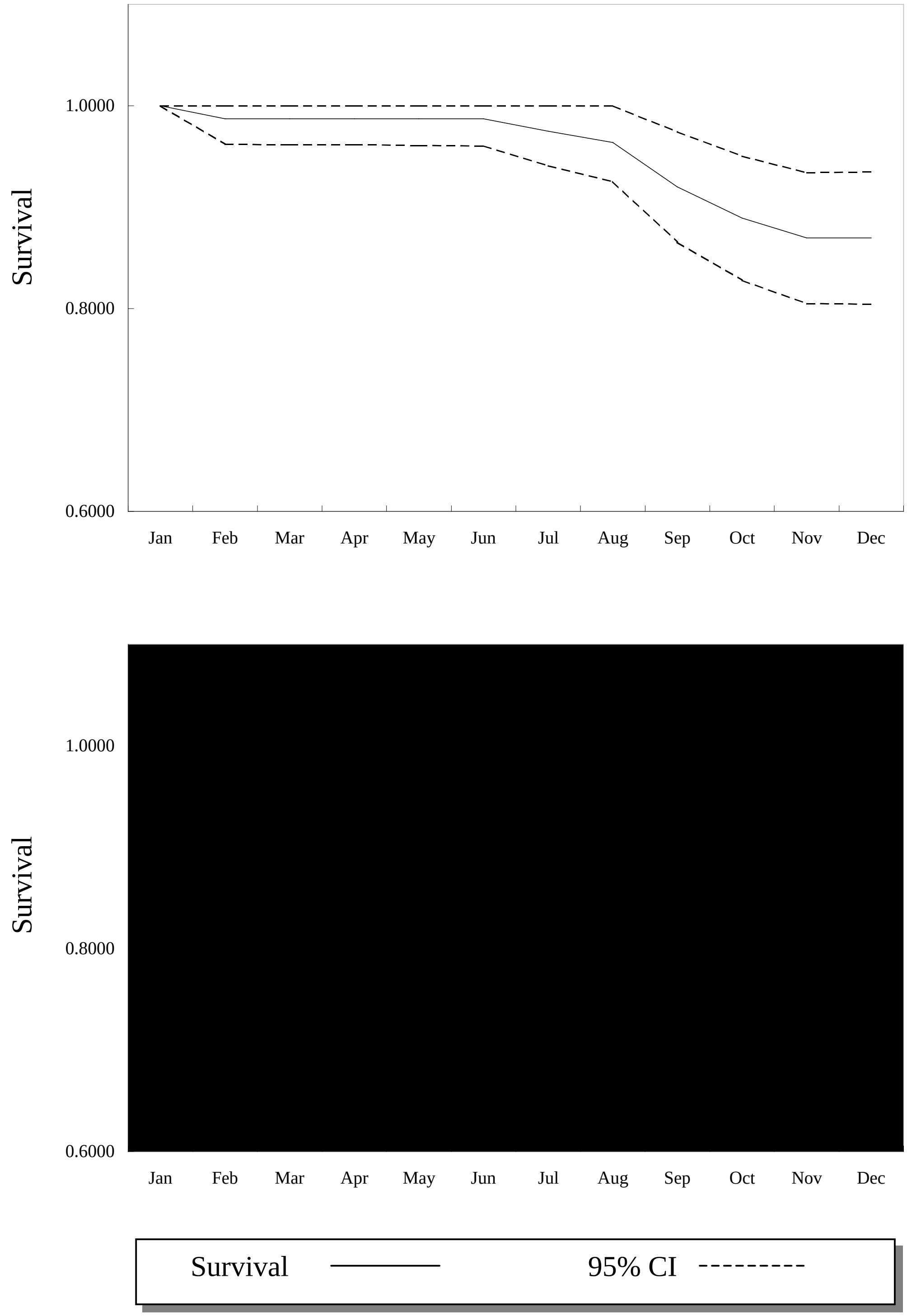

Fig. 16. Survivorship curves and 95% confidence intervals (95% CI) for female black bears on the (A) Okefenokee study area (including hunting) and (B) Osceola study area, Georgia and Florida, 1995–1999.

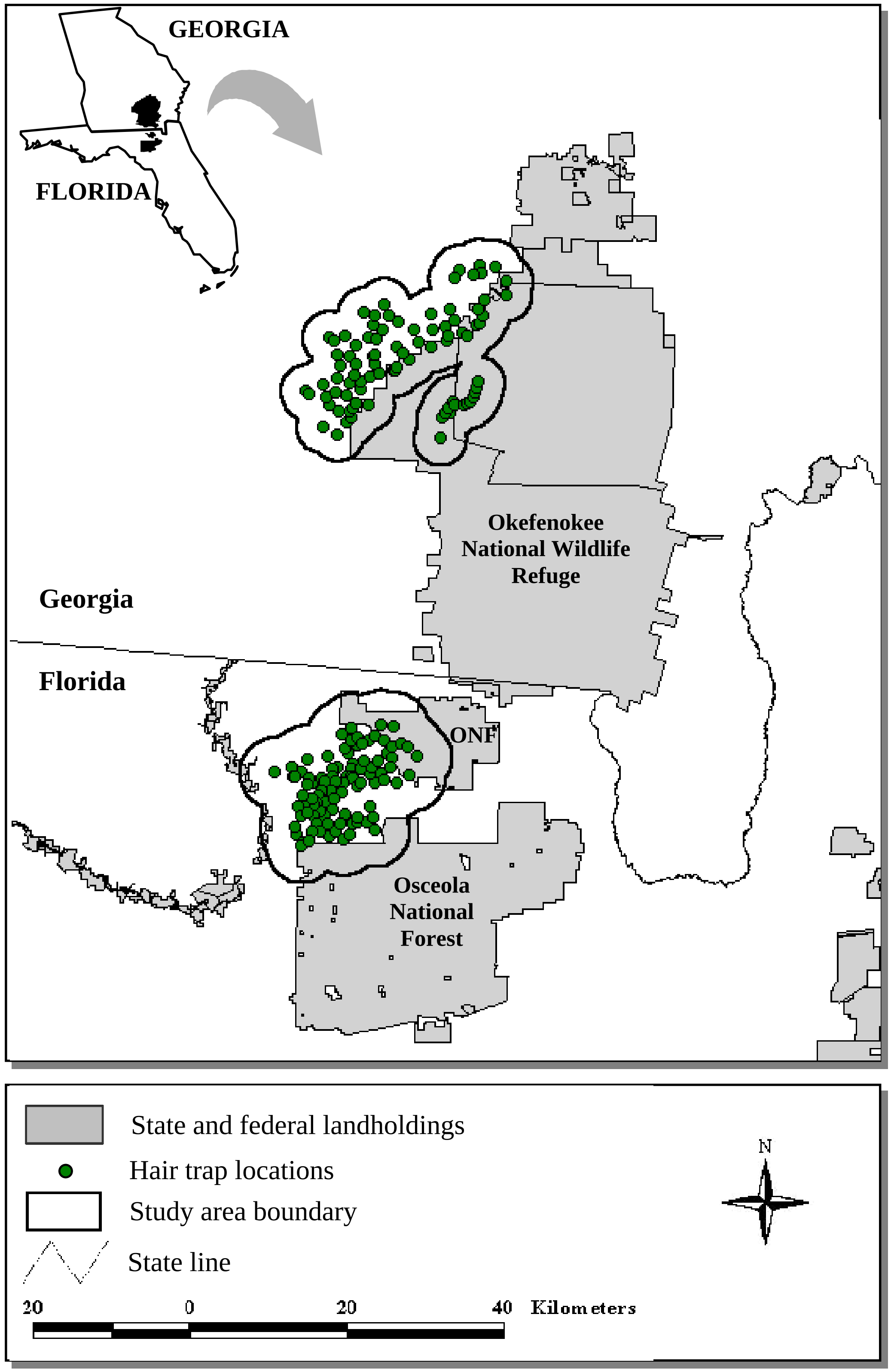

Fig. 17. Locations of barbed-wire hair traps on the Okefenokee and Osceola study areas, Georgia and Florida, 1999.

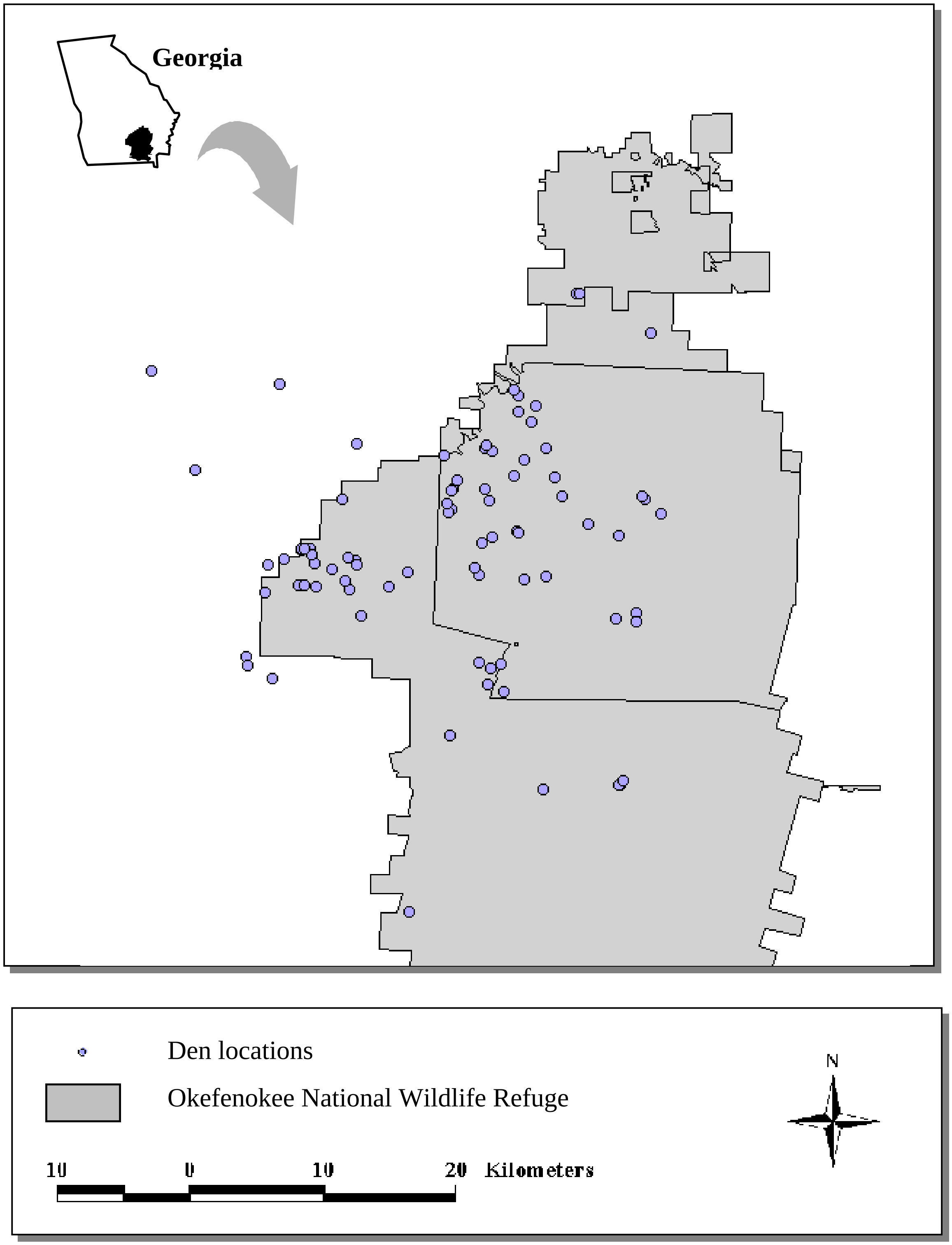

Fig. 18. Locations of black bear den sites on the Okefenokee study area, Georgia, 1995–1998.

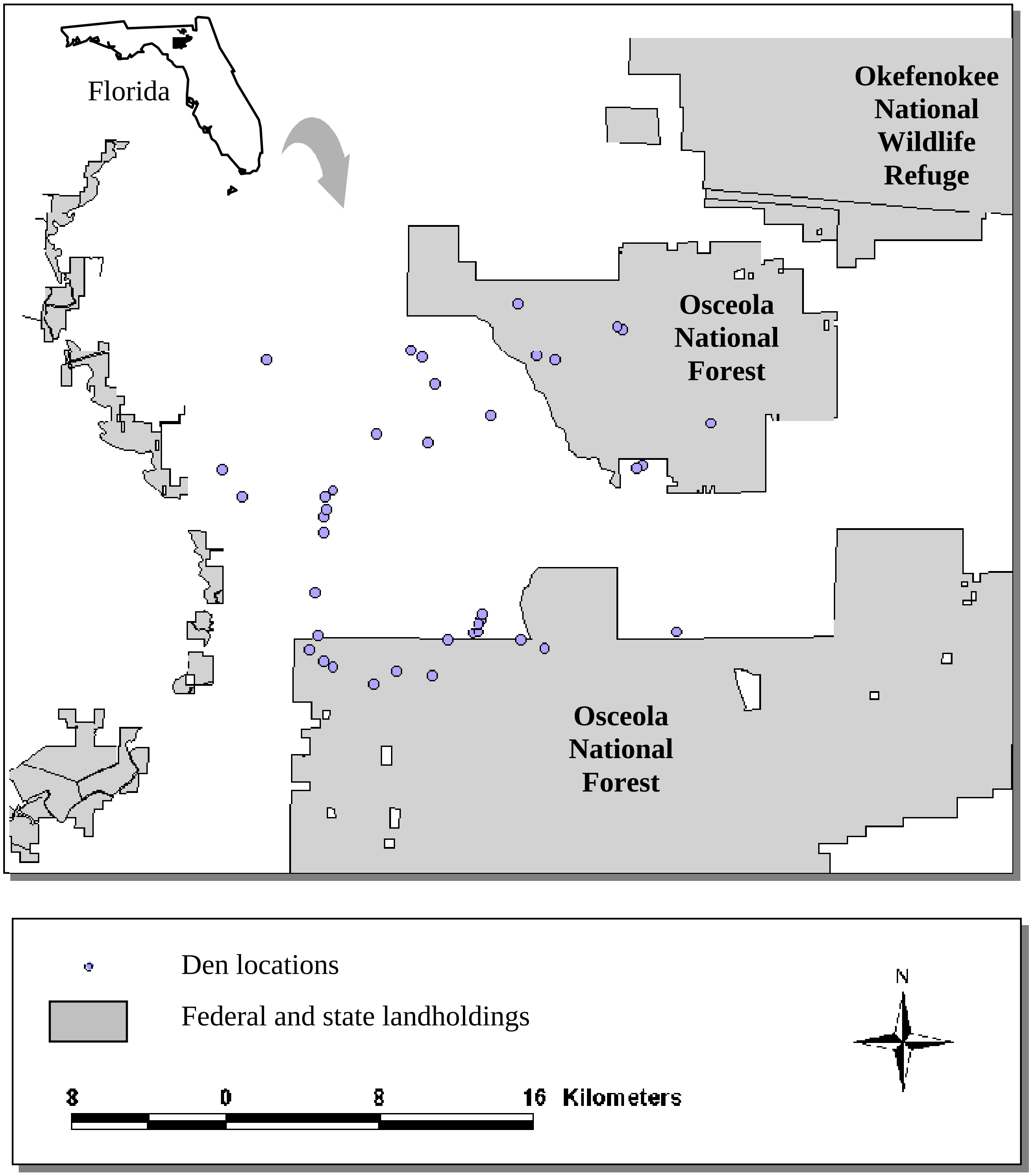

Fig. 19. Locations of black bear den sites on the Osceola study area, Florida, 1996–1998.

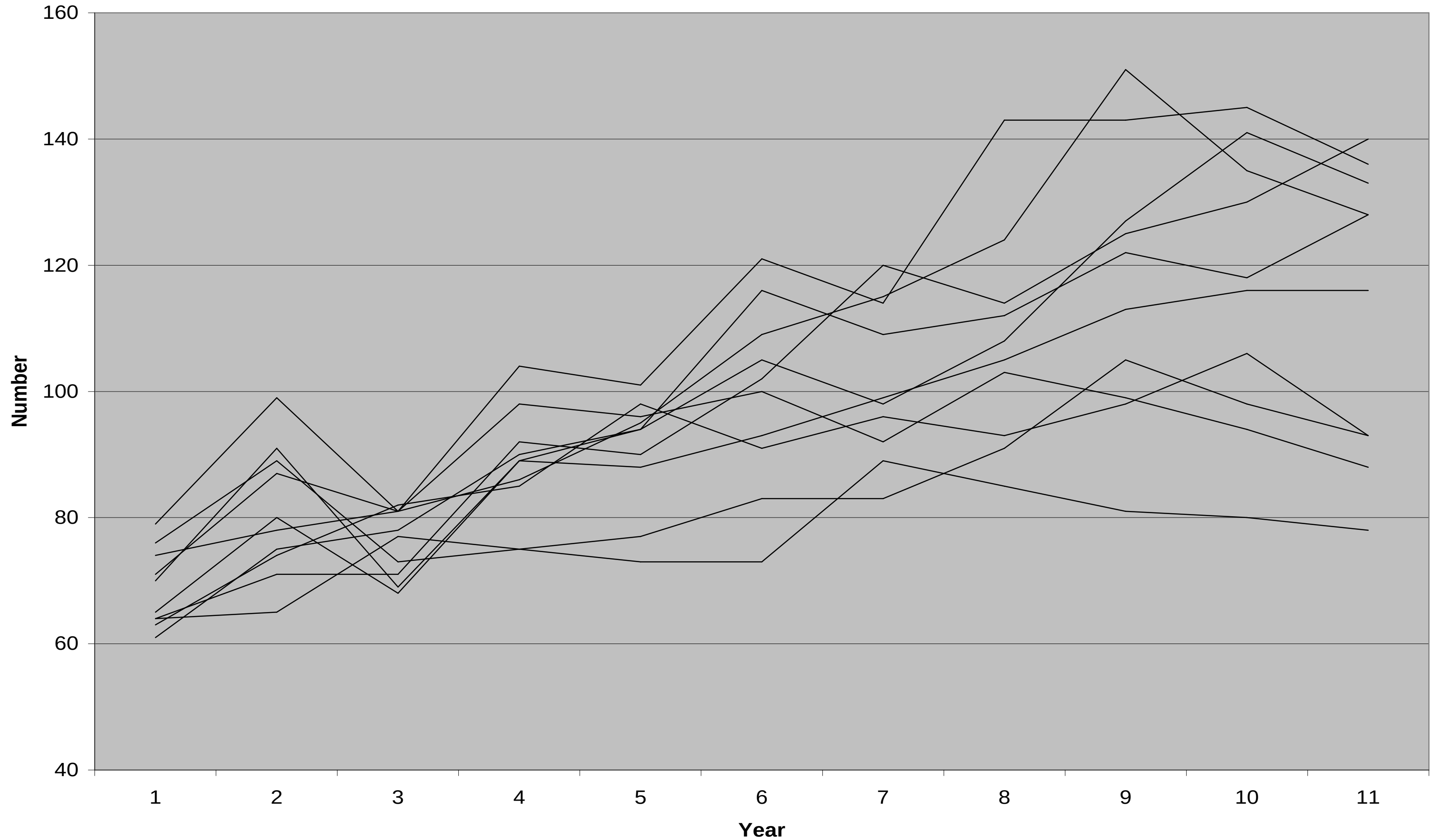

Fig. 20. Population growth on the Okefenokee study area based on 10 stochastic simulations, no harvest, 1999.

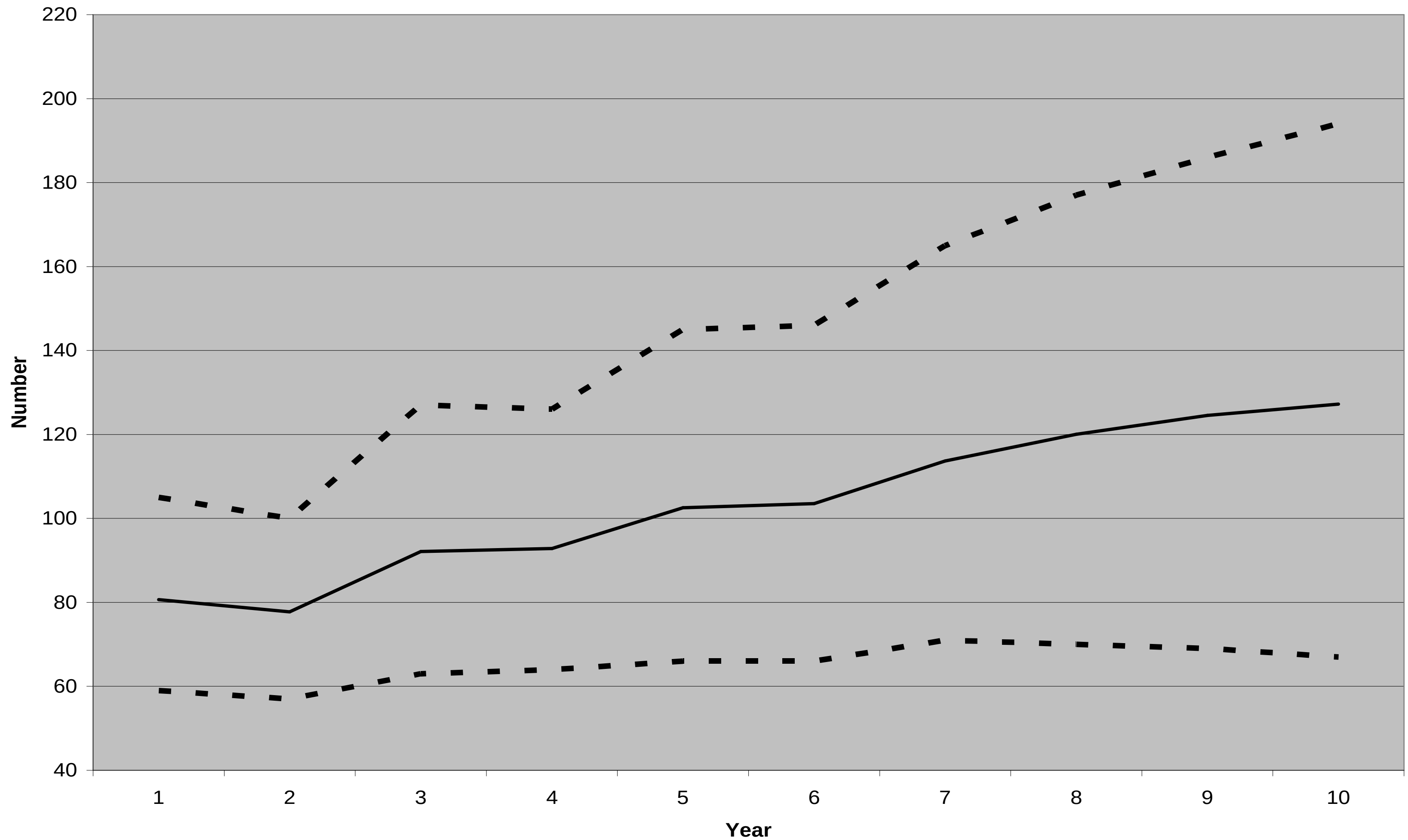

Fig. 21. Average black bear population growth on the Okefenokee study area and upper and lower 95th percentiles, based on 1000 simulations beginning in 1999 with no harvest.

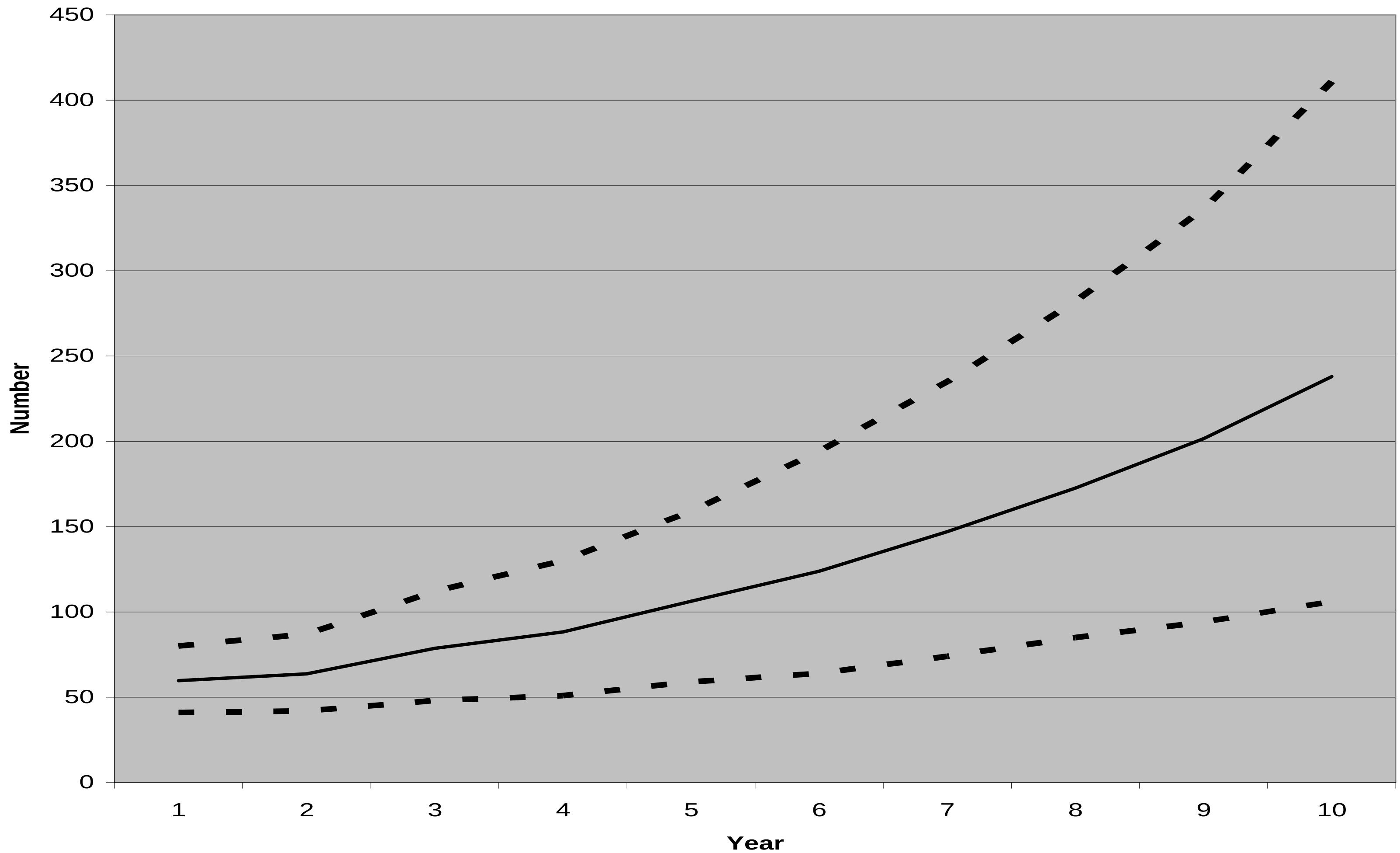

Fig. 22. Average black bear population growth on the Osceola study area and upper and lower 95th percentiles, based on 1000 simulations beginning in 1999.

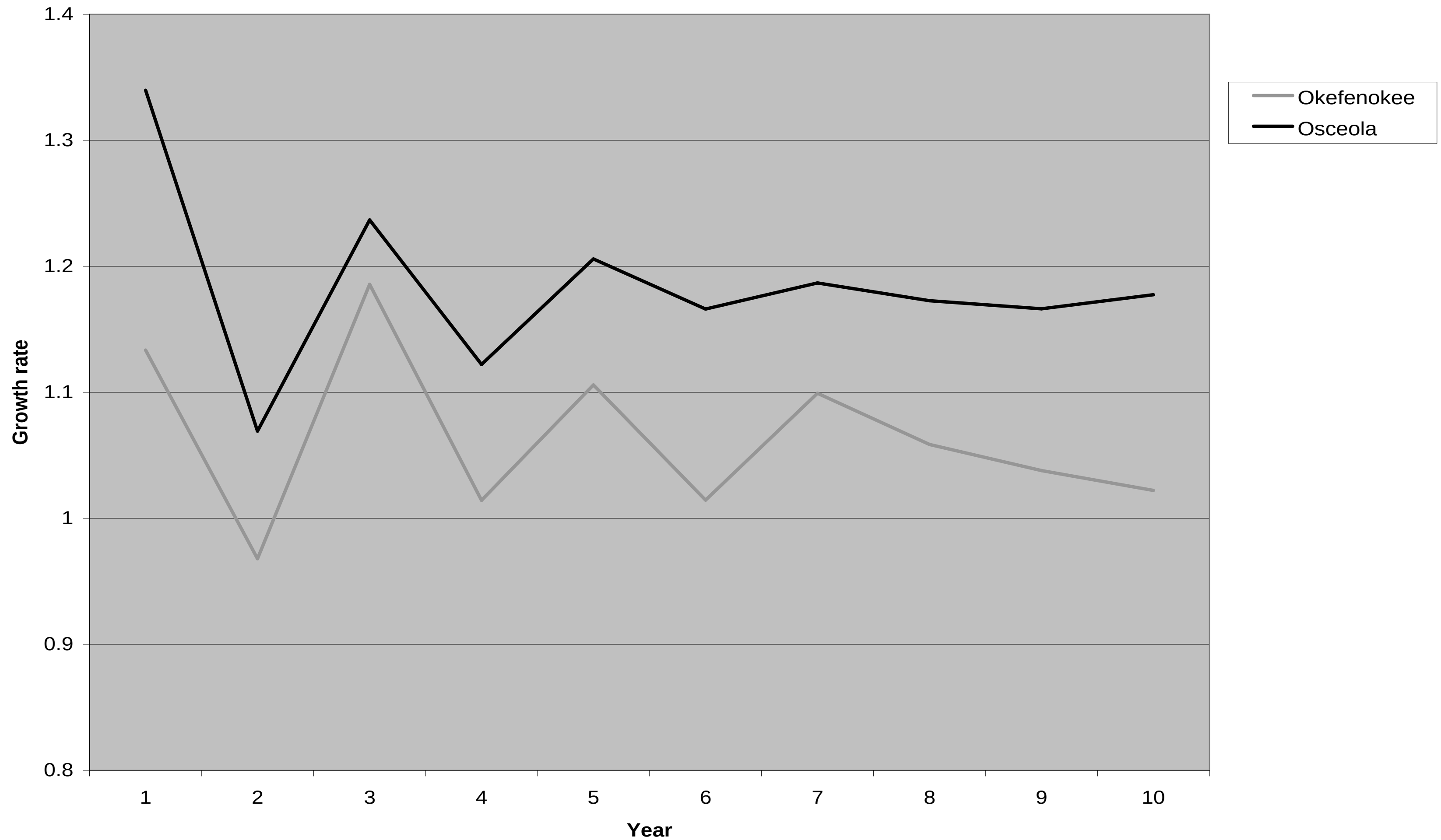

Fig. 23. Average growth rates (λ) of bear populations on the Okefenokee and Osceola study areas, 1000 simulations beginning in 1999 with no harvest.

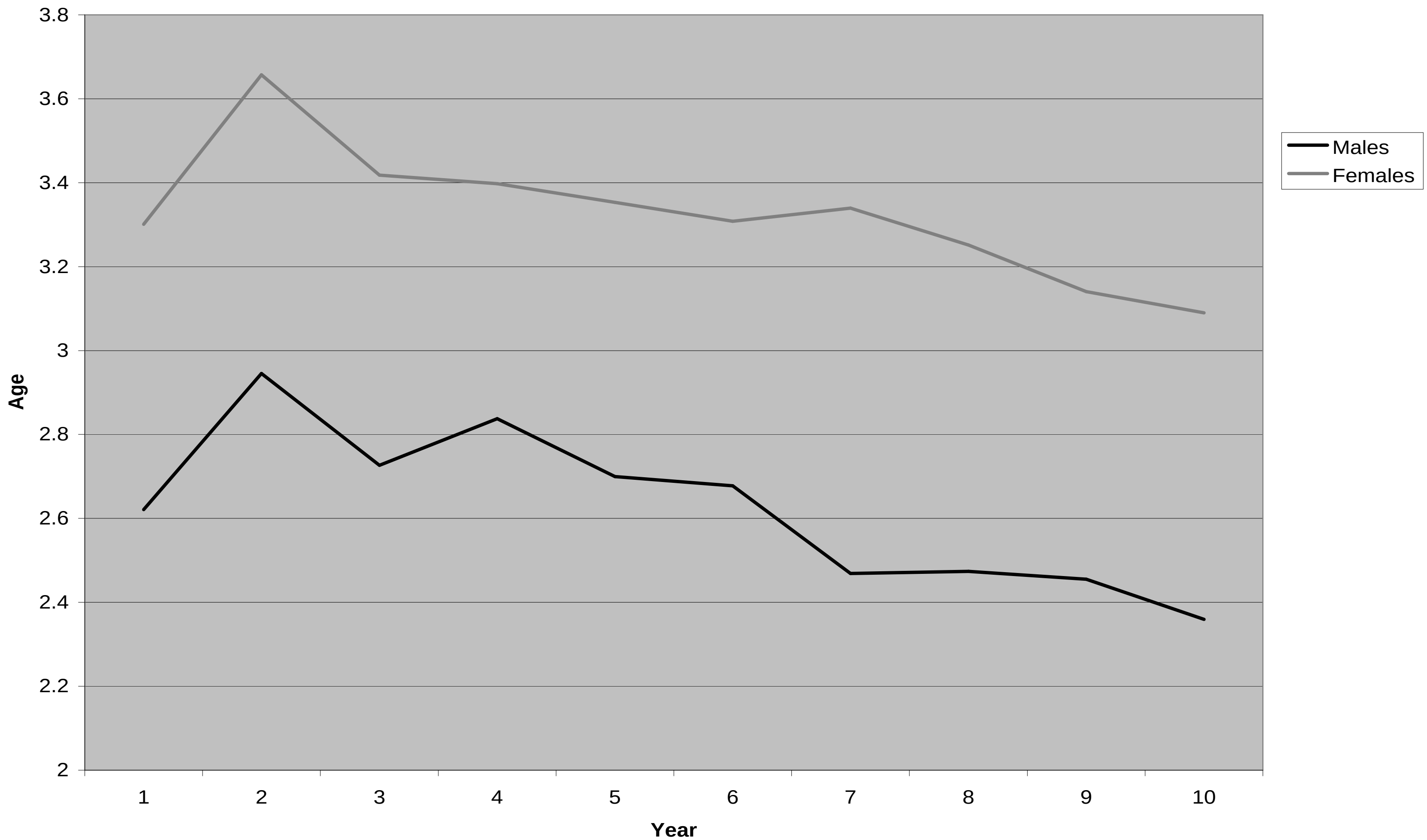

Fig. 24. Projected average ages of the Osceola black bear population, based on 1000 simulations beginning in 1999.

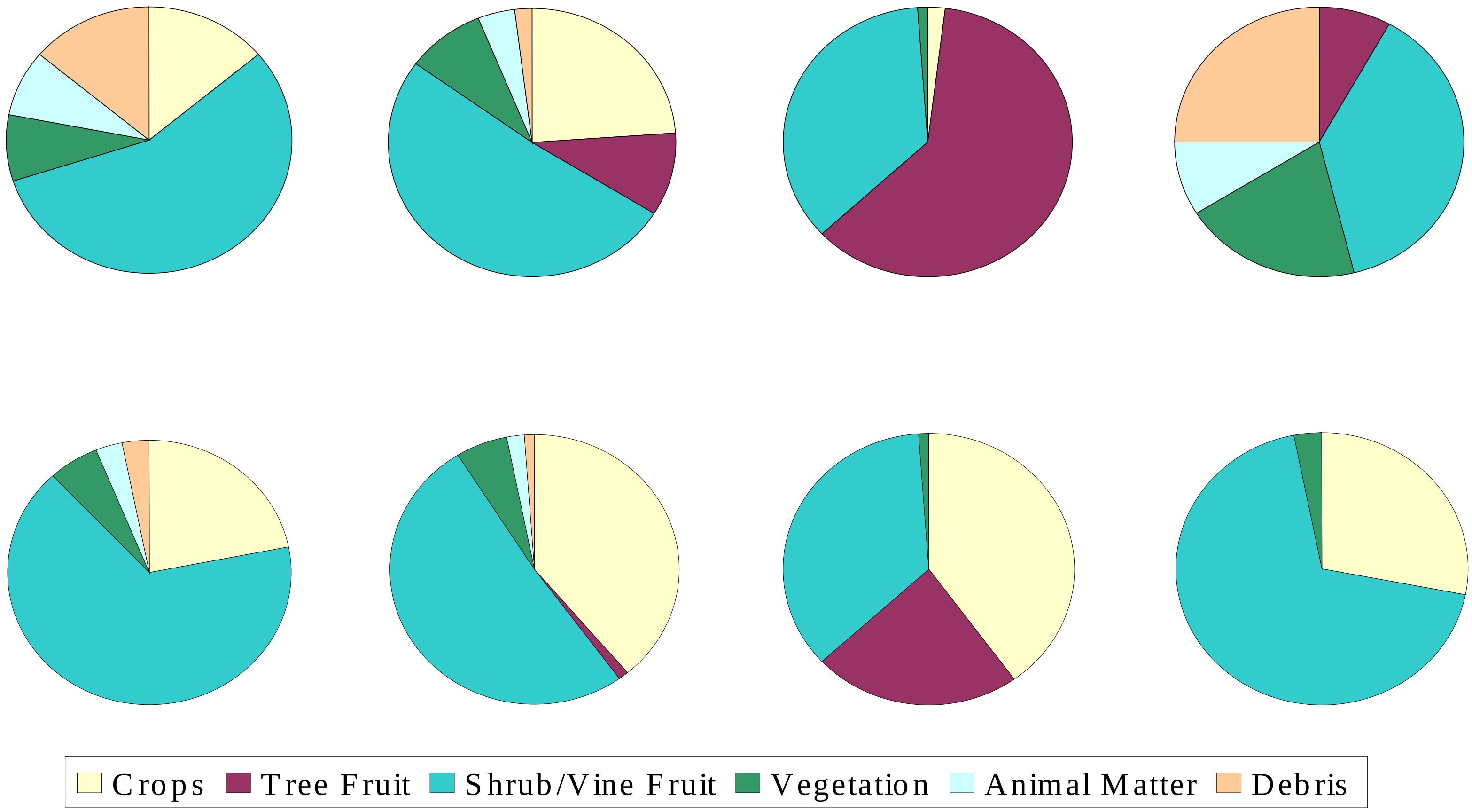

Fig. 25. Seasonal diets (% volume) of black bears on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1999.

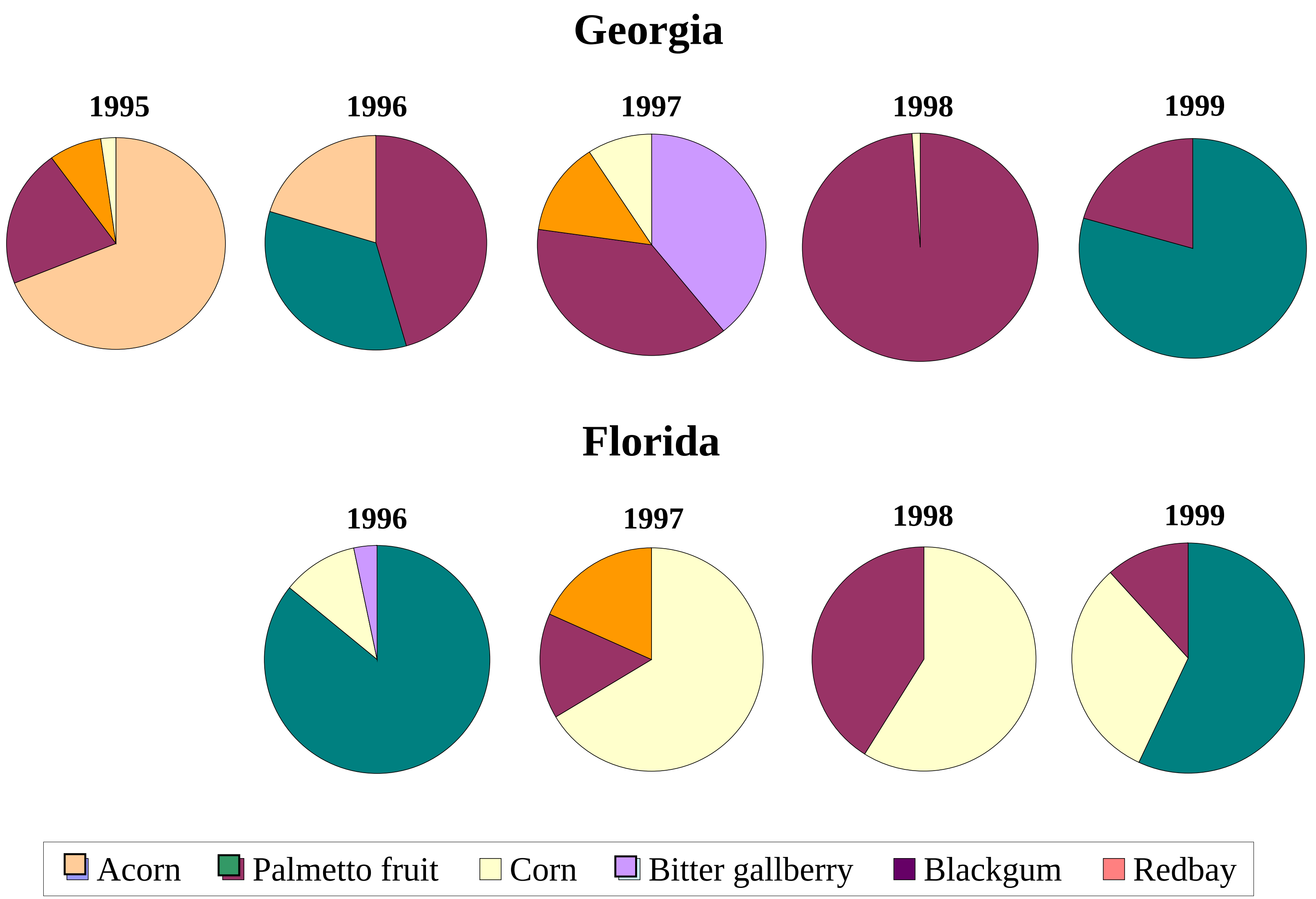

Fig. 26. Fall diets (% volume) of black bears on the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1999.

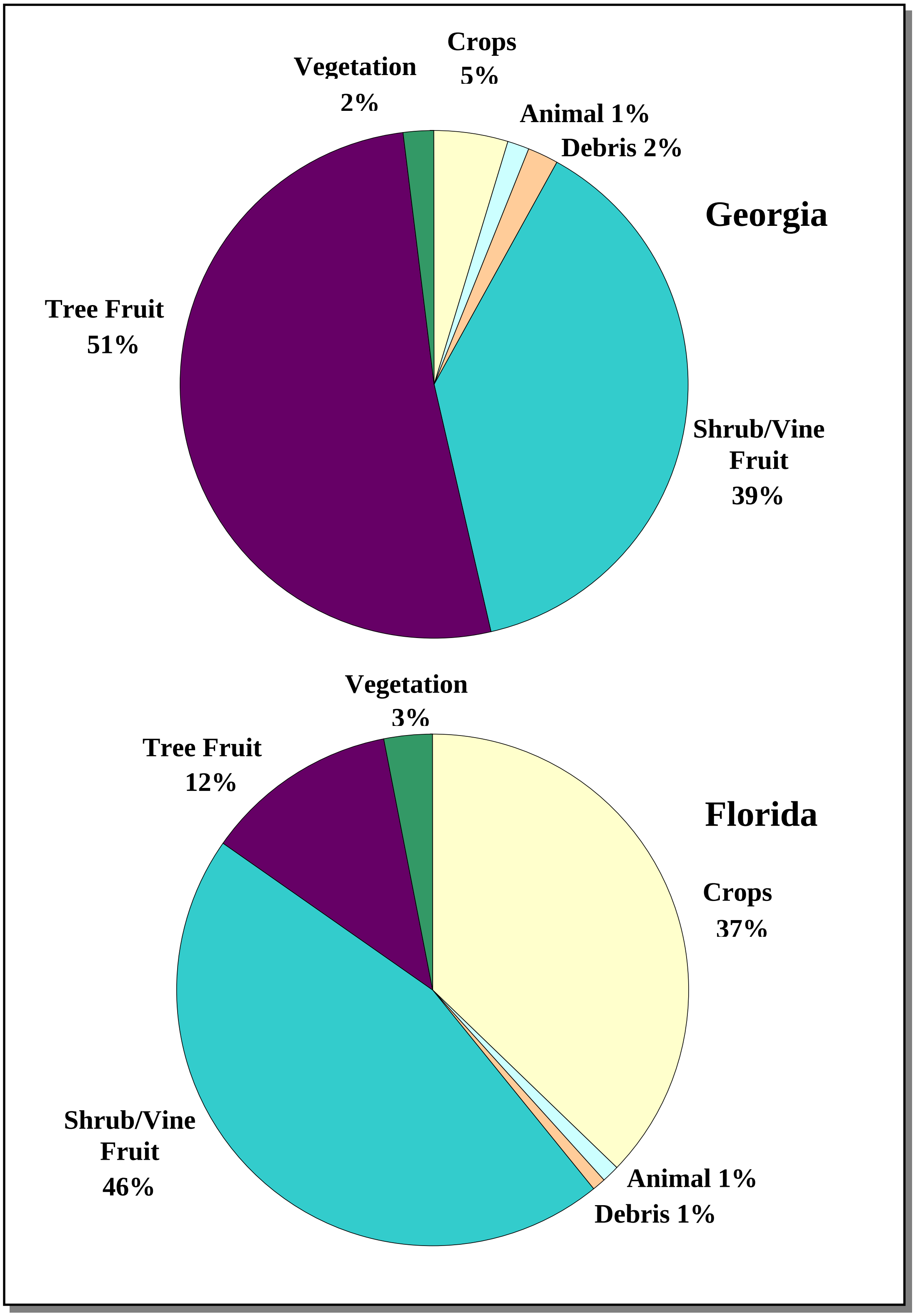

Fig. 27. Annual comparison of major food components (% volume) in the diet of black bears on the Georgia and Florida study areas, 1995–1999.

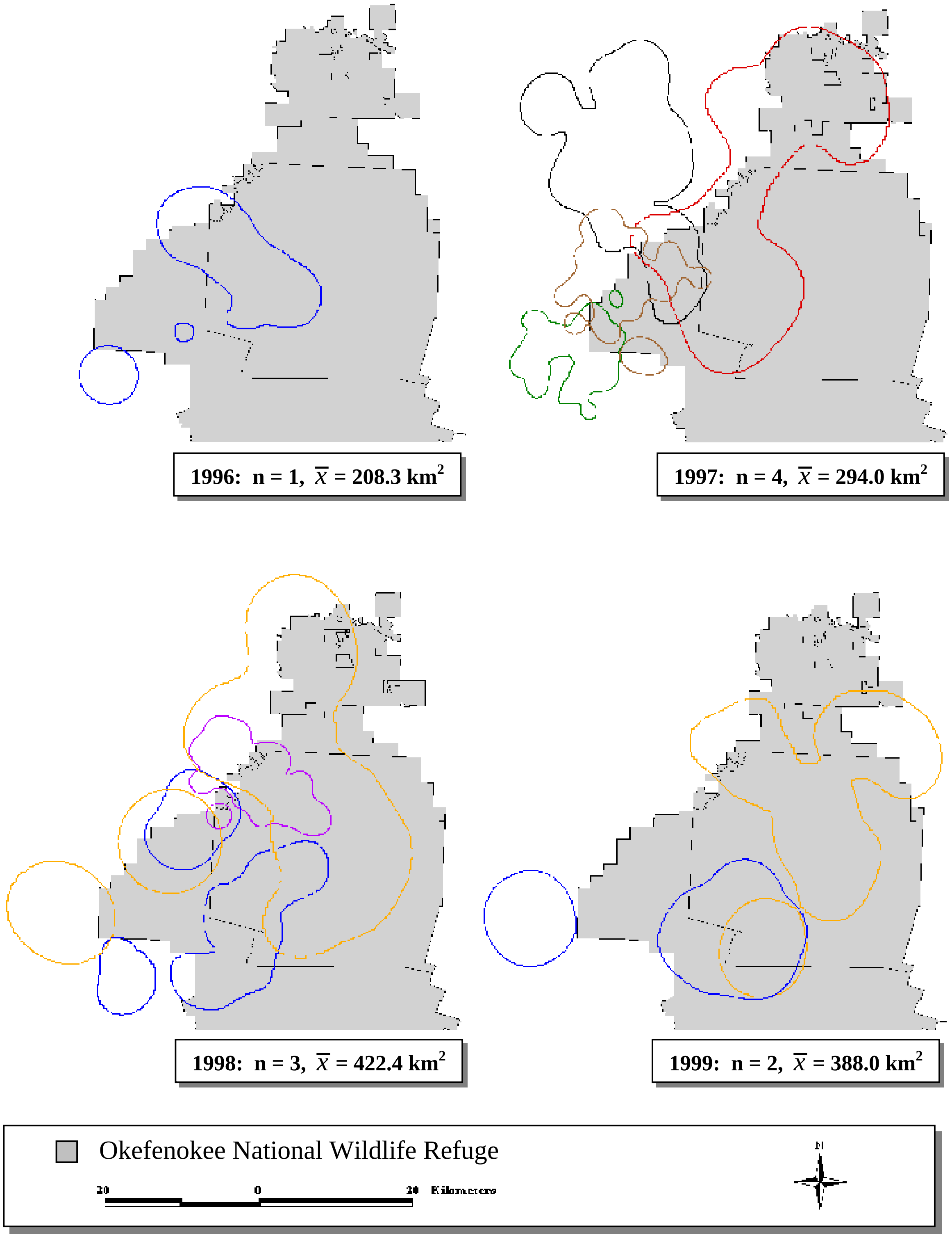

Fig. 29. Annual home range estimates (95% fixed kernel) of male black bears on the Okefenokee study area, Georgia, 1996–1999. Polygons of the same color represent home ranges of individual bears.

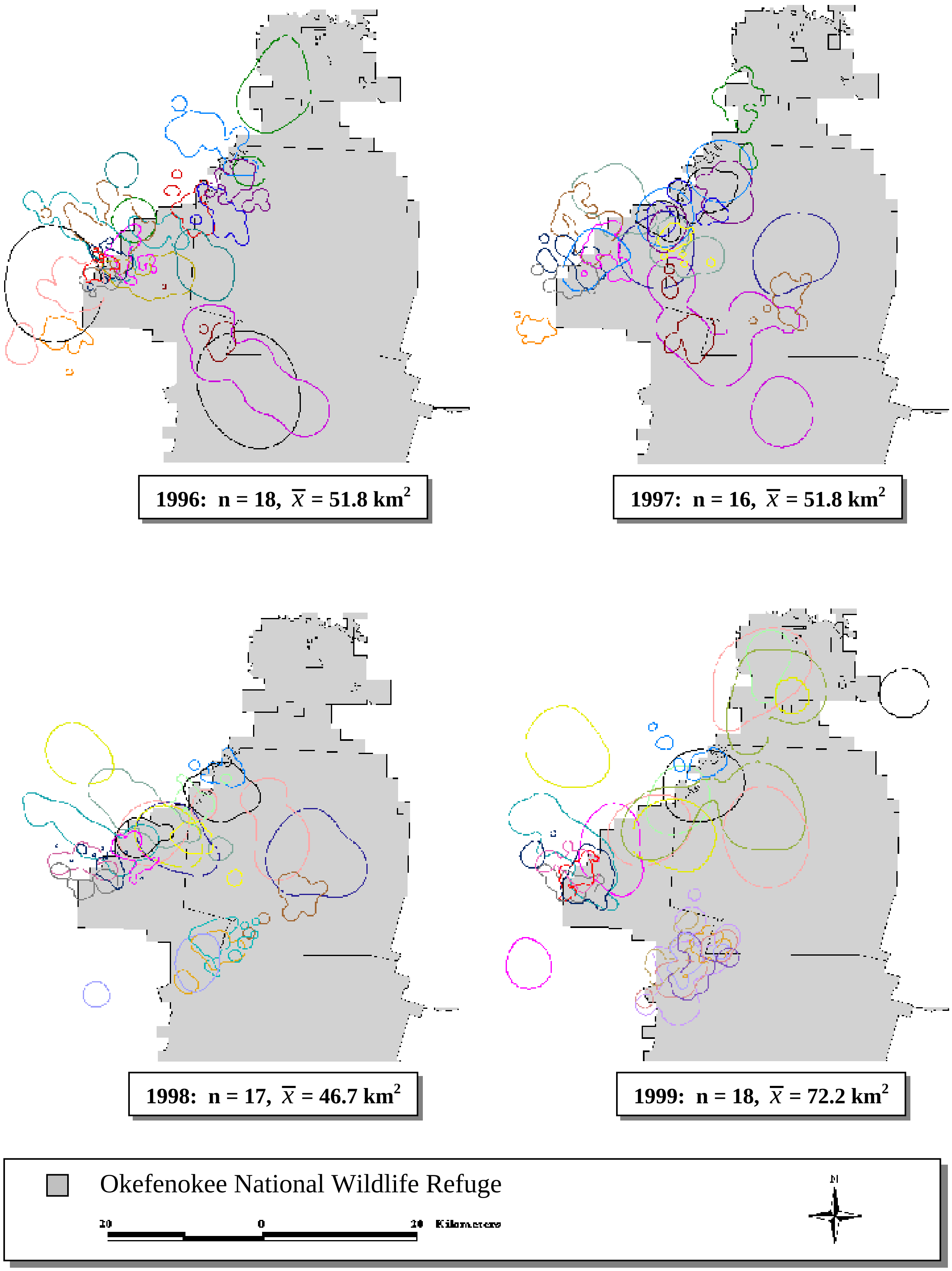

Fig. 30. Annual home range estimates (95% fixed kernel) of female black bears on the Okefenokee study area, Georgia, 1996–1999. Polygons of the same color represent home ranges of individual bears.

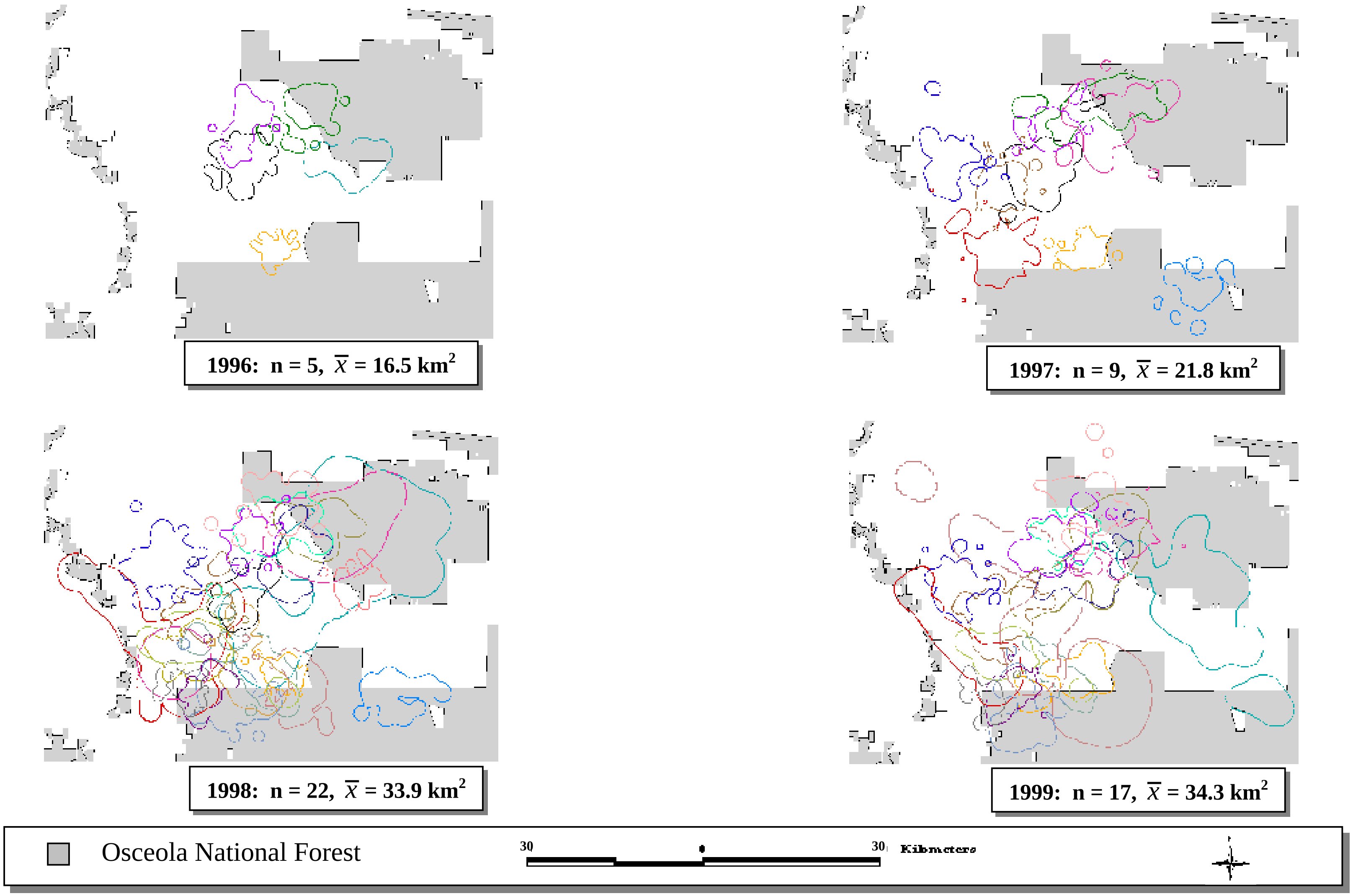

Fig. 31. Annual home range estimates (95% fixed kernel) of female black bears on the Osceola study area, Florida, 1996–1999. Polygons of the same color represent home ranges of individual bears.

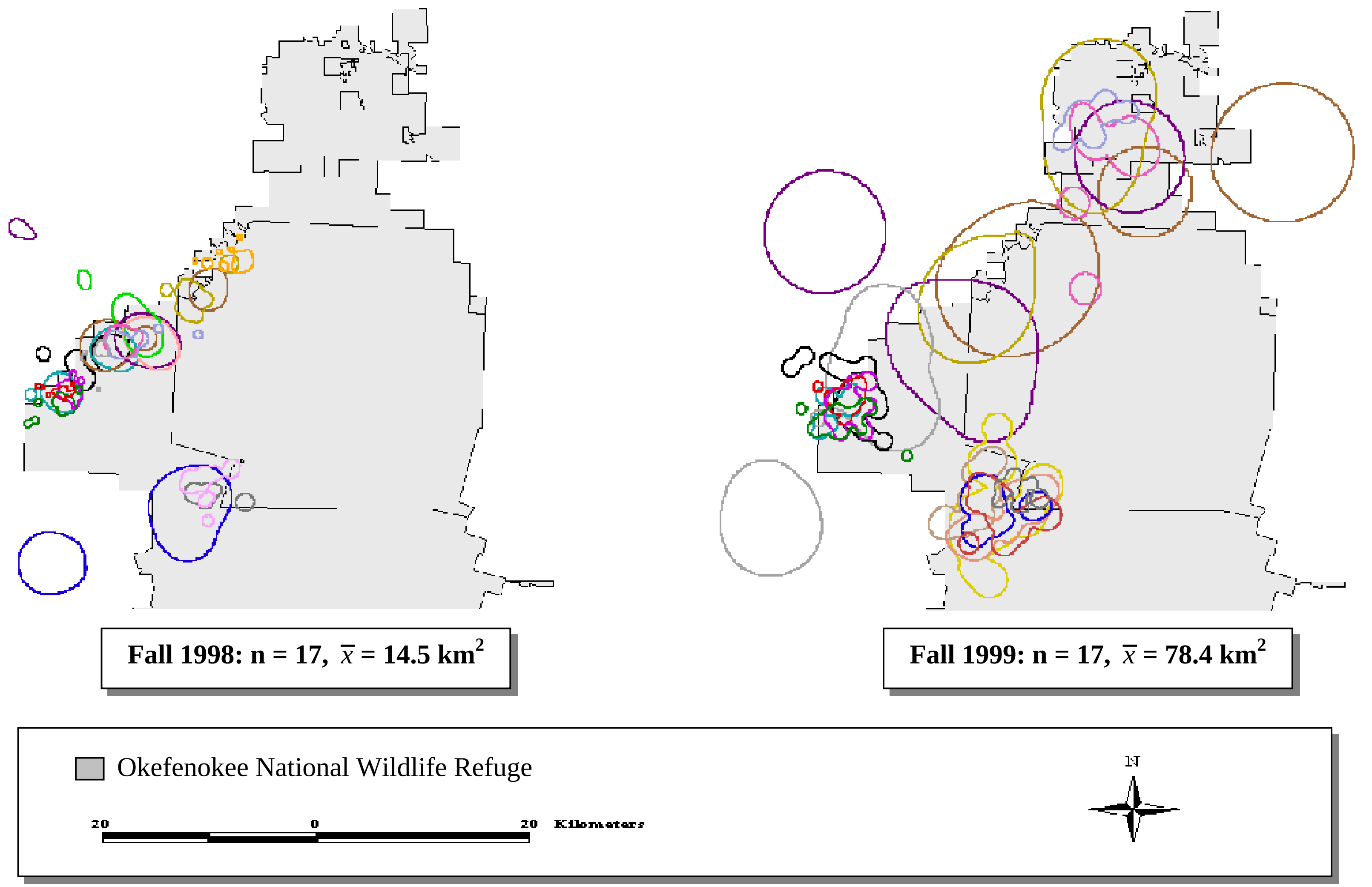

Fig. 32. Seasonal home range estimates (95% fixed kernel) of female black bears during years of abundant (1998) and poor (1999) blackgum production. Polygons of the same color represent home ranges of individual bears.

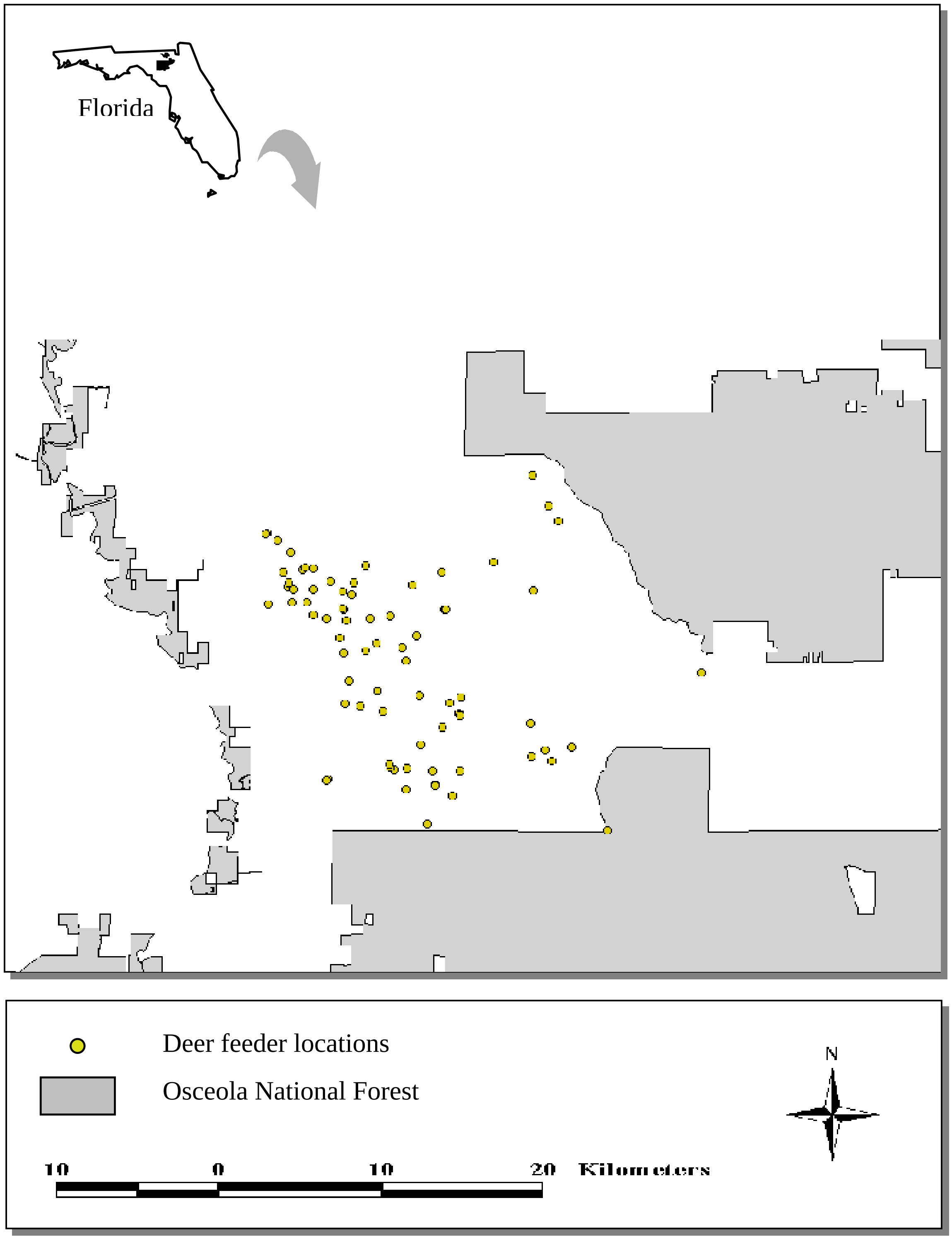

Fig. 33. Locations of deer feeders on the Osceola study area, Florida, 1997–1999.

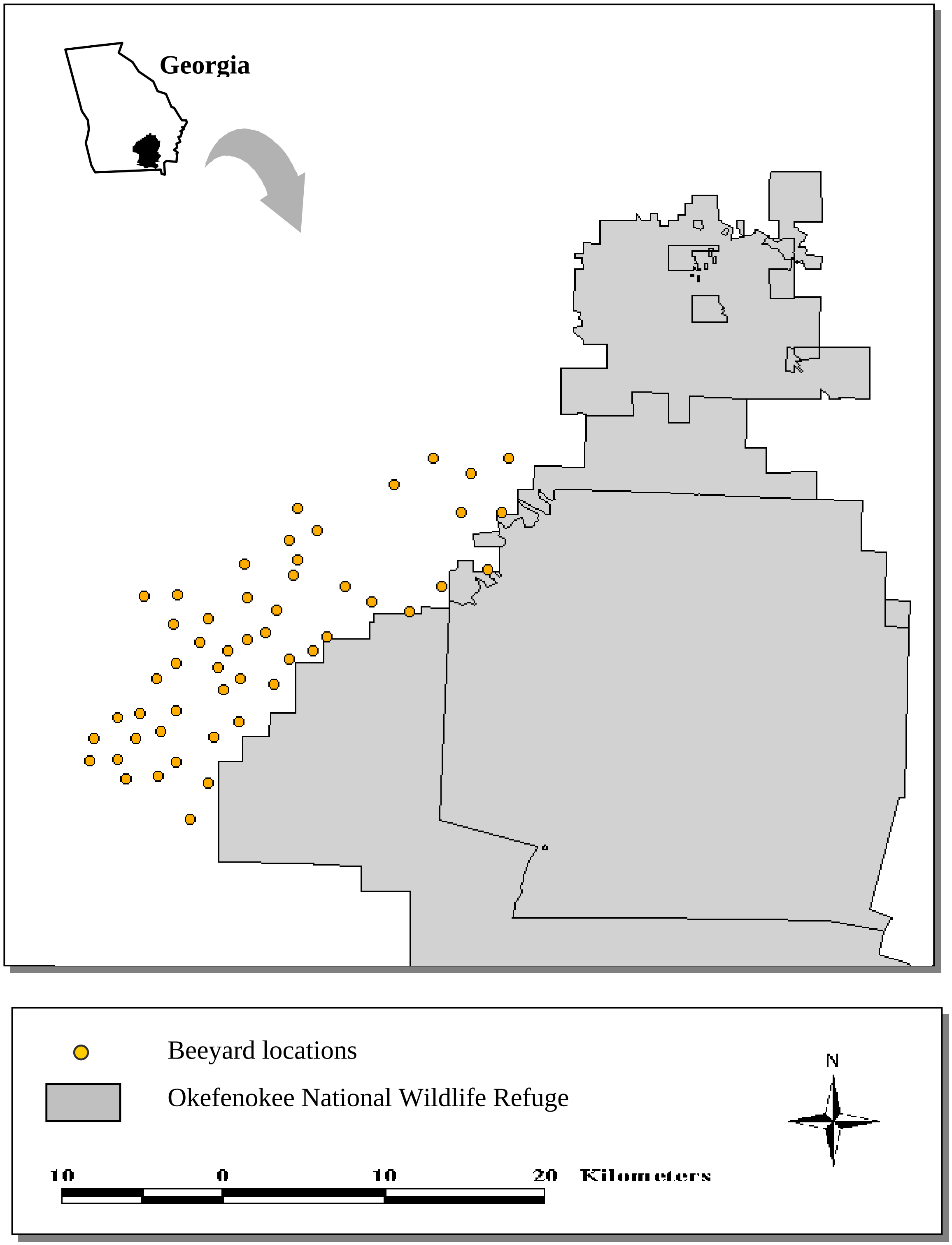

Fig. 34. Locations of beeyards on the Okefenokee study area, Georgia, 1996–1997.

Appendix 1. Laboratory protocol for microsatellite analysis of DNA collected from black bears in the Okefenokee and Osceola study areas, Georgia and Florida, 1995–1999.

DNA Isolation

DNA was extracted from hair follicles using the InstaGene Matrix (Bio-Rad Laboratories, Hercules, California). Specifically, follicles were incubated in the InstaGene Matrix in the presence of Proteinase K at 65°C overnight. This mixture was boiled (100°C) for 8–10 minutes, followed by centrifugation at 10,000–12,000 rpm. The resulting supernatant was used in PCR reactions.

First Stage

Microsatellite DNA amplification was performed in 2 stages. *First Stage* analysis consisted of the amplification of 8 microsatellite DNA loci using the PCR primers described in Paetkau and Strobeck (1994) and Paetkau *et al.* (1995). These loci are G1A, G1D, G10B, G10C, G10L, G10M, G10P, and G10X.

First Stage PCR

Each PCR reaction consisted of 1.5 µl of genomic DNA extract, 0.875 X PCR buffer (59 mM Tris-HCl, pH 8.3; 15 mM $(NH_4)_2SO_4$; 9 mM β-mercaptoethanol; 6 mM EDTA), 2.25 mM $MgCl_2$, 0.2 mM dNTPs, 0.15–0.43 µM of each primer (forward primer fluorescently labeled with TET, FAM, or HEX; Applied Biosystems (ABI), Foster City, California), 1.2 units of Taq polymerase (ABI), and deionized water added to achieve the final volume of 15 µl. The amplification cycle consisted of an initial denaturing at 94°C for 2 min followed by 35 cycles of 94°C denaturing for 30 sec, 56°C annealing for 30 sec, and 72°C extension for 1 min. Cycling culminated with a 5-min extension at 72°C. Thermal cycling was performed in an MJ DNA Engine PTC 200 (MJ Research, Watertown, Massachusetts) configured with a heated lid.

Fragment Analysis

Generally, 1 µl of PCR product was diluted 1:1 with deionized water and thoroughly mixed. One µl of this dilution was added to 12 µl of deionized formamide and 0.5 µl of the internal size standard GENESCAN-500 (ABI). Alternatively, PCR products of separate multiplexed reactions (2–3 loci each) and multiple separate reactions (2–4) were combined and analyzed without dilution. Loci were identified in these multiplexed samples by virtue of their characteristic molecular mass and attached fluorescent label. The size standard contained DNA fragments fluorescently labeled with the dye phosphoramidite TAMRA (red). This PCR product/size standard/formamide mixture was heat denaturated at 95°C for 3 min and placed immediately on ice for at least 5 min. The mixture was subjected to capillary electrophoresis on an ABI PRISM 310 Genetic Analyzer (i.e., automated sequencer). Fluorescently labeled DNA fragments were analyzed, and genotype data generated using GeneScan software (ABI). GENOTYPER v. 2.0 (ABI) DNA fragment analysis software was used to score, bin, and output allelic (and genotypic) designations for each bear sample.

Statistical Analyses

The multilocus genotype generated for each individual from the series of PCR amplifications was analysed to determine the uniqueness of each hair sample. Estimates of individual pair-wise genetic distances, using the proportion of shared alleles algorithm, was calculated using a 32-bit version of Microsat 1.5d (Eric Minch, Stanford University, California).

Observed genotype frequencies were tested for consistency with Hardy-Weinberg and linkage equilibrium expectations using randomization tests implemented by GENEPOP 3.1 (Raymond and Rousset 1995). The Hardy-Weinberg test used the Markov chain randomization test of Guo and Thompson (1992) to estimate exact 2-tailed *P*-values for each locus. Bonferroni adjustments (Rice 1989) were used to determine statistical significance for these tests. Linkage disequilibrium tests used the randomization method of Raymond and Rousset (1995) for all pairs of loci. The amount of genetic variation in each sample was summarized by gene diversity (average expected heterozygosity) and the average frequency of unique alleles.

Literature Cited

Guo, S. W., and E. A. Thompson. 1992. Performing the exact test of Hardy-Weinberg proportions for multiple alleles. Biometrics 48:361-372.

Raymond, M., and R. Rousset. 1995. GENEPOP (version 1.2): population genetics software for exact tests and ecumenicism. Journal of Heredity 86:248-249.

Rice, W. R. 1989. Analyzing tables of statistical tests. Evolution 43:223-225.

Appendix 2. Survey used to evaluate the extent of beeyard depredation and general public opinion of beekeepers in and around the Okefenokee study area, Georgia, 1997.

BEEKEEPERS SURVEY

Department of Forestry, Wildlife, & Fisheries
University of Tennessee
in cooperation with the
Georgia Department of Natural Resources

Your responses to the survey are confidential and will not be associated with your name. Once again, we appreciate your assistance in helping us address this issue.

1. How **Many Bee Hives** did you operate in 1997 ? ____________________________

2. How **Many Beeyards** did you operate in 1997 ? _____________________________

3. How **Far Away** are your yards located from the Okefenokee National Wildlife Refuge?

- ☐ YARDS BORDER REFUGE BOUNDARY
- ☐ LESS THAN 1 MILE
- ☐ 1 - 2 MILES
- ☐ 3 - 5 MILES
- ☐ 6 - 10 MILES
- ☐ OVER 10 MILES

4. Which of the following best describes how you **Feel About Bears** in your area?

- ☐ I ENJOY SEEING BEARS
- ☐ I ENJOY SEEING BEARS BUT WORRY ABOUT BEEYARD DAMAGE
- ☐ BEARS ARE A NUISANCE
- ☐ NO OPINION

5. Do you think the **Bear Population** in your area is..?

- ☐ TOO LOW
- ☐ ABOUT RIGHT
- ☐ TOO HIGH
- ☐ NO OPINION

6. In the past 5 years, do you think that **Problems With Bears** in your area have …?

- ☐ DECREASED

- REMAINED ABOUT THE SAME
- INCREASED
- NO OPINION

7. Which of the following best describes how you **Feel About Bear Damage**?

- BEAR DAMAGE IS ACCEPTABLE
- BEAR DAMAGE IS UNWANTED BUT IS RECOGNIZED AS A PART OF BEEKEEPING
- BEAR DAMAGE IS UNACCEPTABLE
- NO OPINION

8. Have you had **Problems** with bears **Raiding** your beeyards in the past 5 years?

- YES
- NO → Skip to Question 19.

9. Please check the years in which **Bear Problems Occurred**.

- 1993
- 1994
- 1995
- 1996
- 1997

10. Over the past 5 years, what **Time of Year** did the raidings occur?
(PLEASE CHECK **ALL** THAT APPLY).

- SPRING
- SUMMER
- FALL
- WINTER

10a. Please check the particular **Time of Year** in which raidings most **Often** occur, if any.

- NONE
- SPRING
- SUMMER
- FALL
- WINTER

11. Do you consider **Bear Damage** to your beeyards to be…

- VERY LIGHT
- LIGHT

- ☐ MODERATE
- ☐ HIGH
- ☐ NO OPINION

12. Please estimate the **Average Dollar Value** that you have lost **Annually** to bear damage over the past 5 years.

- ☐ NONE
- ☐ $500 or less
- ☐ $501 - $1,000
- ☐ $1,001 - $2,000
- ☐ $2,001 - $4,000
- ☐ $4,001 - $6,000
- ☐ $6,001 - $8,000
- ☐ $8,001 - $10,000
- ☐ more than $10,000

13. Within the past 5 years, what was your **Greatest Loss in Dollars** from bear damage in one year?

$________________________________

14. In what **Year** did your greatest loss occur in the past 5 years?

- ☐ 1993
- ☐ 1994
- ☐ 1995
- ☐ 1996
- ☐ 1997

15. In the past 5 years, would you say the **Number of Bear Raids** on your beeyards has..?

- ☐ DECREASED
- ☐ REMAINED ABOUT THE SAME
- ☐ INCREASED
- ☐ NO OPINION

16. If you feel bear damage has increased, what do you believe is the **Major Cause**? (PLEASE CHECK **ONLY ONE**)

- ☐ BEARS HAVE ADAPTED TO RAIDING FOOD RICH BEEYARDS.
- ☐ NO NATURAL FOODS ARE AVAILABLE.
- ☐ MORE BEARS
- ☐ LOSS OF SUITABLE BEAR HABITAT
- ☐ OTHER (Please list)

____

____

17. How many bee hives did you **Lose** to bear damage in 1997 ? ________________

18. How many beeyards did you have **Visited by Bears** in 1997 ? _______________

19. Do you try to **Prevent Bear Damage** to your beeyards?

- □ YES
- □ NO → Skip to question 22.

20. Please: 1). **Check** the **Methods** that you have used to **Prevent** bear damage and
2). **Rate** each method according to its **Effectiveness** (1 - 5) using the following

1 = Not at All	2 = A Little	3 = Somewhat	4 = Quite a Bit	5 = Very Much	X = No Opinion

scale:

Method Used	Effectiveness					
□ NONE	1	2	3	4	5	X
□ SCARE DEVICES	1	2	3	4	5	X
□ ELECTRIC FENCES	1	2	3	4	5	X
□ CHEMICALS	1	2	3	4	5	X
□ TRAPPING	1	2	3	4	5	X
□ SHOOTING	1	2	3	4	5	X
□ RUNNING WITH DOGS	1	2	3	4	5	X
□ OTHER (Please list)						

____

____

21. Please estimate the amount you **Spend Annually** on bear damage **Prevention**.

- □ NONE
- □ $500 or less
- □ $501 - $1,000
- □ $1,001 - $2,000
- □ $2,001 - $4,000
- □ $4,001 - $6,000
- □ $6,001 - $8,000
- □ $8,001 - $10,000
- □ more than $10,000

22. Please **Rate Your Preference** for each of the following methods for addressing bear damage problems to beeyards using the following scale:

1 = Not at All	2 = A Little	3 = Somewhat	4 = Quite a Bit	5 = Very Much	X = No Opinion

1	2	3	4	5	X	LONGER BEAR HUNTING SEASON
1	2	3	4	5	X	INCREASESD BAG LIMIT

1 2 3 4 5 X RELOCATION OF PROBLEM BEARS
1 2 3 4 5 X COMPENSATION FOR BEAR DAMAGE
1 2 3 4 5 X SPECIAL PERMIT HARVESTING OF PROBLEM BEARS
1 2 3 4 5 X ELECTRIC FENCES AROUND BEEYARDS

23. If you had to **Choose 1 Method** for addressing bear damage, which method would you choose?

- ☐ LONGER BEAR HUNTING SEASON
- ☐ INCREASESD BAG LIMIT
- ☐ RELOCATION OF PROBLEM BEARS
- ☐ COMPENSATION FOR BEAR DAMAGE
- ☐ SPECIAL PERMIT HARVESTING OF PROBLEM BEARS
- ☐ ELECTRIC FENCES AROUND BEEYARDS
- ☐ OTHER (Please explain)

____

____

23a. Why did you choose this method over the other methods?

____

____

BEEKEEPER CHARACTERISTICS

The Following information will be helpful in understanding who is being affected by bear damage to beeyards. All responses, however, are voluntary. **Again, your responses are confidential and will not be associated with your name.**

24. Age

- ☐ 25 OR YOUNGER
- ☐ 26 - 35
- ☐ 36 - 45
- ☐ 46 - 55
- ☐ 55 OR OLDER

25. Sex

- ☐ MALE
- ☐ FEMALE

26. Race

- ☐ BLACK
- ☐ WHITE
- ☐ OTHER ______________________

27. Education (please check highest level of school completed).

- ☐ NONE
- ☐ ELEMENTARY
- ☐ JR. HIGH
- ☐ HIGH SCHOOL
- ☐ 2 YRS. COLLEGE
- ☐ 4 YRS. COLLEGE
- ☐ MORE THAN 4 YEARS COLLEGE

28. What is your annual income from honey production?

- ☐ less than $5,000
- ☐ $5,001 - $10,000
- ☐ $10,001 - $15,000
- ☐ $15,001 - $20,000
- ☐ $20,001 - $25,000
- ☐ $25,001 - $30,000
- ☐ more than $30,000

29. How much of your household income do you receive from beekeeping?

- ☐ LESS THAN 10%
- ☐ 10 - 25%
- ☐ 26 - 50%
- ☐ 51 - 75%
- ☐ 76 - 100%

30. Do you hunt bears during Georgia's six day bear season?

- ☐ YES
- ☐ NO

31. What is your primary occupation? ____

____

32. What **other comments** do you have about bear damage to beeyards?

THANK YOU VERY MUCH FOR YOUR COOPERATION!

Appendix 3. Black bear captures on the Okefenokee study area, Georgia, 1995–1998.

Date	Bear ID#	Capture Type	Sex	Weight (kg)	Age (yrs)
06-Jun-95	001	Initial	Male	79.5	7
08-Jun-95	002	Initial	Male	63.6	5
09-Jun-95	003	Initial	Male	72.7	4
10-Jun-95	004	Initial	Male	125.0	10
11-Jun-95	005	Initial	Male	90.9	5
13-Jun-95	003	Recapture	Male	63.6	4
15-Jun-95	001	Recapture	Male	90.9	7
26-Jun-95	007	Initial	Female	54.5	5
26-Jun-95	008	Initial	Male	159.1	5
28-Jun-95	010	Initial	Female	40.9	3
30-Jun-95	011	Initial	Male	54.5	3
01-Jul-95	020	Initial	Male	63.6	3
03-Jul-95	012	Initial	Female	34.1	2
04-Jul-95	021	Initial	Female	45.5	10
05-Jul-95	022	Initial	Male	136.4	7
05-Jul-95	020	Recapture	Male	68.2	3
09-Jul-95	023	Initial	Female	36.4	5
09-Jul-95	011	Recapture	Male	54.5	3
13-Jul-95	021	Recapture	Female	56.8	10
14-Jul-95	024	Initial	Male	34.1	1
18-Jul-95	013	Initial	Male	45.5	2
19-Jul-95	014	Initial	Female	63.6	5
21-Jul-95	025	Initial	Male	68.2	2
26-Jul-95	026	Initial	Male	113.6	5
27-Jul-95	029	Initial	Male	72.7	3
27-Jul-95	030	Initial	Male	70.5	2
29-Jul-95	031	Initial	Female	47.7	2
30-Jul-95	032	Initial	Male	131.8	6
30-Jul-95	033	Initial	Male	43.2	1

Appendix 3. (continued)

Date	ID#	Capture Type	Sex	Weight (kg)	Age (yrs)
02-Aug-95	034	Initial	Male	68.2	4
04-Aug-95	013	Recapture	Male	45.5	2
09-Aug-95	035	Initial	Male	34.1	1
09-Aug-95	036	Initial	Male	125.0	6
09-Aug-95	037	Initial	Female	52.3	7
10-Aug-95	039	Initial	Female	38.6	2
11-Aug-95	015	Initial	Male	90.9	3
12-Aug-95	040	Initial	Female	50.0	10
13-Aug-95	016	Initial	Male	79.5	3
14-Aug-95	017	Initial	Male	81.8	8
16-Aug-95	018	Initial	Male	81.8	4
17-Aug-95	019	Initial	Male	50.0	2
17-Aug-95	040	Recapture	Female	50.0	10
18-Aug-95	027	Initial	Male	61.4	5
20-Aug-95	038	Initial	Male	75.0	3
24-Aug-95	022	Recapture	Male	90.9	7
27-Aug-95	041	Initial	Male	70.5	3
28-Aug-95	042	Initial	Male	131.8	6
29-Aug-95	043	Initial	Male	56.8	2
30-Aug-95	044	Initial	Male	79.5	6
31-Aug-95	015	Recapture	Male	93.2	3
01-Sep-95	045	Initial	Female	56.8	3
01-Sep-95	046	Initial	Female	50.0	4
03-Sep-95	047	Initial	Female	59.1	2
05-Sep-95	048	Initial	Female	61.4	5
06-Sep-95	049	Initial	Male	113.6	9
07-Sep-95	050	Initial	Male	72.7	4
12-Sep-95	051	Initial	Female	52.3	6
12-Sep-95	043	Recapture	Male	63.6	2

Appendix 3. (continued)

Date	ID#	Capture Type	Sex	Weight (kg)	Age (yrs)
15-Sep-95	051	Recapture	Female	52.3	6
18-Sep-95	028	Initial	Male	56.8	2
19-Sep-95	052	Initial	Female	50.0	8
23-Oct-95	053	Initial	Female	45.5	3
24-Oct-95	054	Initial	Female	50.0	7
25-Oct-95	055	Initial	Male	38.6	2
26-Oct-95	056	Initial	Female	52.3	5
30-Oct-95	057	Initial	Male	56.8	3
30-Oct-95	058	Initial	Male	50.0	2
31-Oct-95	059	Initial	Female	50.0	3
31-Oct-95	060	Initial	Female	56.8	6
03-Nov-95	061	Initial	Male	47.7	3
04-Nov-95	055	Recapture	Male	37.7	2
06-Nov-95	062	Initial	Male	61.4	2
07-Nov-95	063	Initial	Female	47.7	5
25-Nov-95	064	Initial	Female	45.5	6
26-Nov-95	065	Initial	Female	50.0	2
04-Dec-95	067	Initial	Female	40.9	10
04-Dec-95	068	Initial	Female	52.3	8
06-Dec-95	070	Initial	Female	40.9	3
16-Jun-96	071	Initial	Female	61.4	6
19-Jun-96	072	Initial	Female	50.0	7
24-Jun-96	073	Initial	Female	45.5	5
24-Jun-96	004	Recapture	Male	129.5	11
24-Jun-96	074	Initial	Male	54.5	1
26-Jun-96	020	Recapture	Male	61.4	4
26-Jun-96	023	Recapture	Female	45.5	6
28-Jun-96	014	Recapture	Female	75.0	6
28-Jun-96	075	Initial	Female	50.0	3

Appendix 3. (continued)

Date	ID#	Type	Sex	Weight (kg)	Age (yrs)
30-Jun-96	076	Initial	Male	50.0	3
30-Jun-96	077	Initial	Female	40.9	5
30-Jun-96	010	Recapture	Female	47.7	4
02-Jul-96	020	Recapture	Male	61.4	4
04-Jul-96	073	Recapture	Female	45.5	6
18-Jul-96	031	Recapture	Female	54.5	3
20-Jul-96	038	Recapture	Male	106.8	4
21-Jul-96	078	Initial	Female	50.0	6
22-Jul-96	074	Recapture	Male	54.5	1
22-Jul-96	038	Recapture	Male	106.8	4
25-Jul-96	079	Initial	Female	40.9	N/A[b]
27-Jul-96	080	Initial	Male	38.6	1
29-Jul-96	021	Recapture	Female	52.3	11
31-Jul-96	081	Initial	Male	120.5	9
15-Aug-96	003	Recapture	Male	118.2	5
18-Aug-96	016	Recapture	Male	84.1	4
22-Aug-96	022	Recapture	Male	113.6	8
24-Aug-96	013	Recapture	Male	68.2	3
25-Aug-96	082	Initial	Female	77.3	N/A
01-Sep-96	083	Initial	Male	61.4	2
25-Sep-96	004	Recapture	Male	113.6	11
03-Oct-96	051	Recapture	Female	68.2	7
20-Oct-96	091	Initial	Female	47.7	3
22-Oct-96	092	Initial	Female	79.5	7
26-May-97	103	Initial	Male	65.9	2
01-Jun-97	084	Initial	Male	56.8	1
09-Jun-97	038	Recapture	Male	136.4	5
11-Jun-97	103	Recapture	Male	61.4	2
13-Jun-97	085	Initial	Male	65.9	1

Appendix 3. (continued)

Date	ID#	Type	Sex	Weight (kg)	Age (yrs)
13-Jun-97	086	Initial	Male	36.4	1
14-Jun-97	013	Recapture	Male	136.4	4
15-Jun-97	043	Recapture	Male	90.9	4
15-Jun-97	104	Initial	Male	72.7	2
16-Jun-97	087	Initial	Male	43.2	1
17-Jun-97	085	Recapture	Male	65.9	1
19-Jun-97	088	Initial	Male	63.6	2
20-Jun-97	089	Initial	Male	59.1	1
21-Jun-97	038	Recapture	Male	147.7	5
03-Jul-97	045	Recapture	Female	68.2	5
13-Jul-97	089	Recapture	Male	72.7	1
15-Jul-97	078	Recapture	Female	50.0	7
20-Jul-97	104	Recapture	Male	75.0	2
21-Jul-97	103	Recapture	Male	70.5	2
23-Jul-97	093	Initial	Male	52.3	2
23-Jul-97	074	Recapture	Male	102.3	2
23-Jul-97	088	Recapture	Male	50.0	2
23-Jul-97	094	Initial	Male	54.5	4
30-Jul-97	016	Recapture	Male	115.9	5
30-Jul-97	093	Recapture	Male	45.5	2
01-Aug-97	084	Recapture	Male	56.8	1
04-Sep-97	049	Recapture	Male	181.8	11
05-Sep-97	095	Initial	Male	77.3	1
06-Sep-97	020	Recapture	Male	102.3	5
08-Sep-97	073	Recapture	Female	56.8	6
10-Sep-97	096	Initial	Male	127.3	5
11-Sep-97	075	Recapture	Female	52.3	4
11-Sep-97	025	Recapture	Male	127.3	4
11-Sep-97	002	Recapture	Male	122.7	7

Appendix 3. (continued)

Date	ID#	Type	Sex	Weight (kg)	Age (yrs)
11-Sep-97	098	Initial	Male	63.6	2
12-Sep-97	105	Initial	Male	45.5	1
14-Sep-97	100	Initial	Female	36.4	N/A
15-Sep-97	101	Initial	Male	145.5	5
22-Sep-97	102	Initial	Female	56.8	4
24-Sep-97	093	Recapture	Male	50.0	2
16-Sep-97	075	Recapture	Female	52.3	4
17-Sep-97	095	Recapture	Male	77.3	1
19-Sep-97	002	Recapture	Male	122.7	7
25-Sep-97	107	Initial	Female	56.8	5
04-Nov-97	108	Initial	Female	59.1	4
08-Nov-97	109	Initial	Female	45.5	2
08-Nov-97	037	Recapture	Female	59.1	9
10-Nov-97	074	Recapture	Male	113.6	2
11-Nov-97	110	Initial	Male	68.2	1
13-Jun-98	110	Recapture	Male	61.4	2
16-Jun-98	131	Initial	Female	50.0	3
17-Jun-98	110	Recapture	Male	61.4	2
17-Jun-98	133	Initial	Male	72.7	4
19-Jun-98	039	Recapture	Female	45.5	5
21-Jun-98	134	Initial	Female	25.0	1
22-Jun-98	043	Recapture	Male	106.8	4
24-Jun-98	093	Recapture	Male	63.6	3
27-Jun-98	135	Initial	Male	125.0	6
27-Jun-98	136	Initial	Male	95.5	3
02-Jul-98	040	Recapture	Female	63.6	13
04-Jul-98	045	Recapture	Female	40.9	6
08-Jul-98	137	Initial	Female	22.7	1
08-Jul-98	138	Initial	Female	27.3	1

Appendix 3. (continued)

Date	ID#	Type	Sex	Weight (kg)	Age (yrs)
12-Jul-98	051	Recapture	Female	56.8	9
13-Jul-98	999[a]	Initial	Female	52.3	3
24-Jul-98	140	Initial	Female	36.4	2
25-Jul-98	141	Initial	Male	34.1	1
26-Jul-98	085	Recapture	Male	93.2	2
27-Jul-98	084	Recapture	Male	68.2	2
29-Jul-98	094	Recapture	Male	63.6	5
30-Jul-98	093	Recapture	Male	61.4	3
30-Jul-98	143	Initial	Female	52.3	4
01-Aug-98	039	Recapture	Female	54.5	5
10-Aug-98	144	Initial	Male	22.7	1
11-Aug-98	037	Recapture	Female	63.6	10
15-Aug-98	003	Recapture	Male	125.0	7
15-Aug-98	145	Initial	Male	50.0	1
17-Aug-98	146	Initial	Male	45.5	1
18-Aug-98	074	Recapture	Male	104.5	3
18-Aug-98	094	Recapture	Male	63.6	5
24-Aug-98	138	Recapture	Female	29.5	1
25-Aug-98	086	Recapture	Male	54.5	2
30-Aug-98	147	Initial	Male	54.5	3
30-Aug-98	105	Recapture	Male	61.4	2
01-Sep-98	148	Initial	Male	109.1	5
05-Sep-98	072	Recapture	Female	61.4	9
08-Sep-98	049	Recapture	Male	136.4	12
08-Sep-98	090[a]	Initial	Male	88.6	5
10-Sep-98	076	Recapture	Male	79.5	5
11-Sep-98	088	Recapture	Male	68.2	3
12-Sep-98	149	Initial	Male	75.0	3
12-Sep-98	087	Recapture	Male	54.5	2

Appendix 3. (continued)

Date	ID#	Type	Sex	Weight (kg)	Age (yrs)
13-Sep-98	020	Recapture	Male	102.3	6
14-Sep-98	073	Recapture	Female	56.8	7
14-Sep-98	150	Initial	Male	54.5	3
16-Sep-98	151	Initial	Male	54.5	1
17-Sep-98	096	Recapture	Male	118.2	6
23-Sep-98	152	Initial	Male	38.6	1

[a] Initial captures of nuisance bears that were relocated onto the study area in 1997.
[b] Tooth not removed for aging due to tooth loss or premature recovery from sedation.

Appendix 4. Trapping summaries for the Okefenokee study area, Georgia, 1995–1998.

Year, trap line	Number of bear Visits	Number of bear Captures	Trap-nights	Trapnights per capture	Success Rate[a] (%)	Capture Rate[b] (%)
1995						
Big Swamp	23	14	346	24.7	4.0	60.9
Cravens	13	12	140	11.7	8.6	92.3
Hickory Hammock	12	9	120	13.3	7.5	75.0
Jamestown	49	18	364	20.2	4.9	36.7
Okefenokee Sportsman	38	25	361	14.4	6.9	65.8
Total	135	78	1,331	17.1	5.9	57.8
1996						
Big Swamp	28	14	402	28.7	3.5	50.0
Cravens	3	2	110	55.0	1.8	66.7
Jamestown	12	8	486	60.8	1.6	66.7
Okefenokee Sportsman	14	9	583	64.8	1.5	64.3
Total	57	33	1,581	47.9	2.1	57.9
1997						
Big Swamp	59	17	353	20.8	4.8	28.8
Boone Island	9	5	84	16.8	6.0	55.6
Hopkins Tram	0	0	81	---	0.0	---
Jamestown	73	9	579	64.3	1.6	12.3
Okefenokee Sportsman	59	18	594	33.0	3.0	30.5
Total	200	49	1,691	34.5	2.9	24.5
1998						
Big Swamp	125	16	373	23.3	4.3	12.8
Jamestown	174	14	644	46.0	2.2	8.0
Okefenokee Sportsman	108	19	729	38.4	2.6	17.6
Pocket	11	4	76	19.0	5.3	36.4
Total	418	53	1,822	34.4	2.9	12.7
Grand total	810	213	6,425	30.2	3.3	26.3

[a] Success rate is the number of bear captures divided by the number trapnights.
[b] Capture rate is the number of bear captures divided by the number bear visits.

Appendix 5. Black bear captures on the Osceola study area, Florida, 1996–1998.

Date	Bear ID#	Capture Type	Sex	Weight (kg)	Age (yrs)
07-Jun-96	201	Initial	Male	147.7	4
08-Jun-96	202	Initial	Female	38.6	3
11-Jun-96	203	Initial	Male	75.0	3
14-Jun-96	205	Initial	Female	68.2	4
14-Jun-96	207	Initial	Male	79.5	2
15-Jun-96	204	Initial	Male	88.6	3
16-Jun-96	209	Initial	Male	145.5	3
17-Jun-96	206	Initial	Female	52.3	3
17-Jun-96	208	Initial	Female	45.5	2
20-Jun-96	210	Initial	Male	63.6	3
24-Jun-96	211	Initial	Female	59.1	5
24-Jun-96	213	Initial	Male	147.7	6
25-Jun-96	207	Recapture	Male	79.5	2
26-Jun-96	215	Initial	Female	59.1	7
29-Jun-96	212	Initial	Male	25.0	1
29-Jun-96	214	Initial	Male	90.9	3
30-Jun-96	216	Initial	Male	61.4	2
08-Jul-96	217	Initial	Female	25.0	1
11-Jul-96	219	Initial	Female	56.8	3
12-Jul-96	218	Initial	Male	54.5	3
13-Jul-96	220	Initial	Male	40.9	1
14-Jul-96	221	Initial	Male	43.2	1
15-Jul-96	222	Initial	Male	97.7	2
20-Jul-96	223	Initial	Male	47.7	3
21-Jul-96	224	Initial	Female	63.6	3
24-Jul-96	225	Initial	Male	63.6	1
24-Jul-96	226	Initial	Female	59.1	5
26-Jul-96	227	Initial	Female	31.8	1
26-Jul-96	209	Recapture	Male	145.5	3

Appendix 5. (continued)

Date	Bear ID#	Capture Type	Sex	Weight (kg)	Age (yrs)
26-Jul-96	228	Initial	Female	52.3	3
29-Jul-96	229	Initial	Male	147.7	6
30-Jul-96	230	Initial	Male	45.5	1
01-Aug-96	231	Initial	Male	150.0	6
10-Aug-96	232	Initial	Female	75.0	3
17-Aug-96	233	Initial	Male	43.2	2
18-Aug-96	225	Recapture	Male	63.6	1
27-Aug-96	234	Initial	Female	N/A[a]	4
02-Sep-96	235	Initial	Female	77.3	6
16-Dec-96	236	Initial	Male	181.8	4
02-Jan-97	216	Recapture	Male	113.6	3
15-Jun-97	237	Initial	Male	43.2	1
16-Jun-97	248	Initial	Female	59.1	10
18-Jun-97	249	Initial	Male	38.6	2
22-Jun-97	238	Initial	Male	61.4	1
22-Jun-97	239	Initial	Male	68.2	1
23-Jun-97	227	Recapture	Female	52.3	2
24-Jun-97	218	Recapture	Male	79.5	4
27-Jun-97	211	Recapture	Female	84.1	6
28-Jun-97	207	Recapture	Male	109.1	3
01-Jul-97	215	Recapture	Female	54.5	8
02-Jul-97	240	Initial	Male	93.2	5
09-Jul-97	241	Initial	Male	65.9	1
10-Jul-97	242	Initial	Male	111.4	2
15-Jul-97	241	Recapture	Male	61.4	1
15-Jul-97	239	Recapture	Male	63.6	1
17-Jul-97	243	Initial	Female	43.2	2
17-Jul-97	214	Recapture	Male	106.8	4
17-Jul-97	266	Initial	Male	143.2	5

Appendix 5. (continued)

Date	ID#	Capture Type	Sex	Weight (kg)	Age (yrs)
04-Aug-97	244	Initial	Female	40.9	1
05-Aug-97	245	Initial	Male	147.7	7
06-Aug-97	246	Initial	Female	97.7	7
14-Aug-97	247	Initial	Male	129.5	11
17-Aug-97	216	Recapture	Male	104.5	3
19-Aug-97	220	Recapture	Male	65.9	2
21-Aug-97	225	Recapture	Male	95.5	2
22-Aug-97	250	Initial	Female	50.0	1
22-Aug-97	251	Initial	Male	145.5	3
27-Aug-97	252	Initial	Male	125.0	13
29-Aug-97	246	Recapture	Female	79.5	7
02-Sep-97	233	Recapture	Male	77.3	3
03-Sep-97	253	Initial	Female	45.5	3
03-Sep-97	250	Recapture	Female	47.7	1
04-Sep-97	254	Initial	Female	68.2	9
04-Sep-97	255	Initial	Male	100.0	3
05-Sep-97	260	Initial	Female	45.5	1
06-Sep-97	219	Recapture	Female	50.0	4
07-Sep-97	256	Initial	Male	118.2	6
08-Sep-97	261	Initial	Male	52.3	3
09-Sep-97	254	Recapture	Female	68.2	9
11-Sep-97	257	Initial	Female	68.2	1
11-Sep-97	236	Recapture	Male	163.6	5
12-Sep-97	224	Recapture	Female	54.5	4
14-Sep-97	253	Recapture	Female	45.5	3
15-Sep-97	240	Recapture	Male	125.0	6
16-Sep-97	263	Initial	Male	120.5	5
18-Sep-97	220	Recapture	Male	75.0	2
20-Sep-97	234	Recapture	Female	86.4	5

Appendix 5. (continued)

Date	ID#	Capture Type	Sex	Weight (kg)	Age (yrs)
16-Jun-98	258	Initial	Male	34.1	1
16-Jun-98	259	Initial	Female	25.0	1
18-Jun-98	205	Recapture	Female	N/A	6
19-Jun-98	258	Recapture	Male	34.1	1
20-Jun-98	202	Recapture	Female	45.5	5
21-Jun-98	206	Recapture	Female	59.1	5
21-Jun-98	267	Initial	Male	181.8	5
22-Jun-98	264	Initial	Male	38.6	2
24-Jun-98	268	Initial	Female	27.3	1
25-Jun-98	269	Initial	Male	31.8	1
29-Jun-98	205	Recapture	Female	N/R	6
02-Jul-98	207	Recapture	Male	131.8	4
02-Jul-98	270	Initial	Male	59.1	2
02-Jul-98	269	Recapture	Male	31.8	1
03-Jul-98	248	Recapture	Female	63.6	11
08-Jul-98	271	Initial	Female	43.2	5
09-Jul-98	215	Recapture	Female	65.9	9
10-Jul-98	209	Recapture	Male	159.1	5
11-Jul-98	272	Initial	Female	54.5	4
14-Jul-98	211	Recapture	Female	59.1	7
15-Jul-98	208	Recapture	Female	56.8	4
16-Jul-98	273	Initial	Male	29.5	1
22-Jul-98	258	Recapture	Male	34.1	1
22-Jul-98	274	Initial	Female	31.8	1
23-Jul-98	275	Initial	Female	27.3	1
24-Jul-98	231	Recapture	Male	147.7	8
01-Aug-98	232	Recapture	Female	77.3	5
02-Aug-98	206	Recapture	Female	59.1	5
04-Aug-98	274	Recapture	Female	31.8	1

Appendix 5. (continued)

Date	ID#	Type	Sex	Weight (kg)	Age (yrs)
05-Aug-98	276	Initial	Male	106.8	3
06-Aug-98	277	Initial	Male	25.0	1
07-Aug-98	216	Recapture	Male	102.3	5
08-Aug-98	226	Recapture	Female	72.7	7
11-Aug-98	278	Initial	Male	102.3	3
14-Aug-98	220	Recapture	Male	90.9	3
16-Aug-98	263	Recapture	Male	136.4	6
16-Aug-98	245	Recapture	Male	159.1	8
17-Aug-98	244	Recapture	Female	36.4	2
19-Aug-98	279	Initial	Male	104.5	4
19-Aug-98	233	Recapture	Male	84.1	4
28-Aug-98	279	Recapture	Male	104.5	4
29-Aug-98	203	Recapture	Male	136.4	5
16-Sep-98	216	Recapture	Male	90.9	5
17-Sep-98	253	Recapture	Female	59.1	4
21-Sep-98	283	Initial	Male	27.3	1

[a] Weight not available due to premature recovery from sedation.

Appendix 6. Trapping summaries for the Osceola study area, Florida, 1996–1998.

Year, trap line	Number of bear Visits	Number of bear Captures	Trap-nights	Trapnights per capture	Success Rate[a] (%)	Capture Rate[b] (%)
1996						
Banker's Trust	23	20	630	31.5	3.2	87.0
Bear Bay	12	9	485	53.9	1.9	75.0
Low Road	13	10	339	33.9	2.9	76.9
Total	48	39	1,454	37.3	2.7	81.3
1997						
Banker's Trust	56	15	763	50.9	2.0	26.8
Bear Bay	30	16	783	48.9	2.0	53.3
Low Road	21	17	283	16.6	6.0	81.0
Total	107	48	1,829	38.1	2.6	44.9
1998						
Banker's Trust	206	21	600	28.6	3.5	10.2
Bear Bay	139	20	803	40.2	2.5	14.4
Low Road	73	4	425	106.3	0.9	5.5
Total	418	45	1,828	40.6	2.5	10.8
Grand total	573	132	5,111	38.7	2.6	23.0

[a] Success rate is the number of bear captures divided by the number trapnights.
[b] Capture rate is the number of bear captures divided by the number bear visits.

Appendix 7. Characteristics of beeyards located on the Okefenokee study area, Georgia, 1996–1998.

Beeyard	Fenced area (m^2)	Fence height (m)	Number of hives	Number of supers	Wire type	Number of fence strands	Power source	Bear depredations
01	109.5	86.4	37	11	barbed	5	car battery	0
02	177.6	83.8	24	20	smooth	3	car battery	0
03	171.5	88.9	31	12	barbed	5	car battery	0
04	151.0	58.4	34	28	smooth	3	car battery	0
05	453.7	73.7	24	18	barbed/smooth	4	solar panel	0
06	416.4	78.7	18	4	barbed/smooth	4	car battery*	0
07	429.8	81.3	35	16	smooth	4	solar panel	0
08	212.7	82.6	26	18	smooth	4	solar panel	0
09	434.2	83.8	25	19	barbed	4	solar panel	1
10	724.8	78.7	29	27	smooth	4	solar panel	1
11	414.8	76.2	30	20	smooth	4	solar panel	0
12	469.2	76.2	14	10	smooth	4	car battery	0
13	521.4	82.6	26	19	barbed/smooth	4	solar panel	0
14	335.4	83.8	20	12	barbed/smooth	4	solar panel	1
15	144.0	78.7	18	8	smooth	3	car battery	0
16	115.9	88.9	23	20	smooth	3	car battery	0
17	524.6	86.3	26	21	smooth	4	car battery*	1
18	285.8	73.7	28	26	smooth	4	solar panel	1
19	465.5	81.2	22	18	smooth	4	solar panel	0
20	338.9	86.4	29	19	barbed	4	car battery	1
21	376.6	68.6	16	14	barbed	4	car battery	1
22	212.2	73.7	32	11	smooth	3	car battery	0
23	177.3	68.6	26	19	barbed/smooth	4	car battery	0

Appendix 7. (continued)

Beeyard	Fenced area (m^2)	Fence height (m)	Number of hives	Number of supers	Wire type	Number of fence strands	Power source	Bear depredations
24	272.9	68.6	20	12	barbed	4	car battery	0
25	210.2	78.7	25	19	barbed	3	car battery	0
26	345.3	96.5	29	27	barbed	5	car battery	0
27	212.8	100.3	41	30	barbed	5	car battery	0
28	196.0	80.0	34	29	smooth	3	solar panel	0
29	226.7	121.9	23	16	woven/barbed	3	car battery	0
30	268.6	78.7	16	10	smooth	4	car battery	0
31	154.0	83.8	27	19	smooth	4	car battery	0
32	285.2	91.4	24	20	smooth	4	solar panel	0
33	292.6	76.2	31	12	smooth	3	solar panel	0
34	298.9	68.6	34	28	smooth	3	solar panel	0
35	226.4	80.0	41	22	smooth	3	solar panel	0
36	338.1	83.8	32	8	smooth	4	solar panel	0
37	215.1	87.6	76	131	smooth	4	car battery	0
38	359.5	83.8	41	9	barbed/smooth	4	solar panel	0
39	126.2	87.6	23	32	smooth	4	car battery	0
40	157.5	84.8	26	19	smooth	3	car battery	0
41	308.8	69.9	37	11	smooth	3	solar panel	0
42	923.1	124.4	26	19	woven/barbed	3	car battery	0
43	517.4	106.7	20	12	woven/barbed	2	car battery	0
44	537.2	121.9	24	18	woven/barbed	2	car battery	0
45	307.1	94.0	18	4	barbed	4	car battery	0
46	495.7	124.5	35	16	woven/barbed	2	car battery	0
47	395.8	106.7	26	18	woven/barbed	2	car battery	0
48	347.8	94.0	25	19	barbed	6	car battery	0

Appendix 7. (continued)

Beeyard	Fenced area (m^2)	Fence height (m)	Number of hives	Number of supers	Wire type	Number of fence strands	Power source	Bear depredations
49	594.6	124.5	29	27	woven/barbed	3	car battery	0
50	418.8	127.0	30	20	woven/barbed	2	car battery	0
51	526.8	127.0	24	18	woven/barbed	2	car battery	0

*Car battery with solar addition
Woven – woven wire or “hog wire”
Barbed – standard gauge bared wire
Smooth – standard gauge electrical wire